THE COLLECTING NET

Vol. XVII, No. 1 SATURDAY, JULY 4, 1942 Annual Subscription, $1.00 Single Copies, 30 Cents.

WORK OF THE *ATLANTIS* AND THE *ANTON DOHRN*

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Director,
Woods Hole Oceanographic Institution

The entry of this country into the war caught the *Atlantis* returning from a temperature survey of the area southwest of Bermuda, but she reached Woods Hole a few days later without incident. During January the ship was made ready for sea under war time conditions. All port holes and deck lights were blacked out. Canvases were fitted to shield the companion ways. Extra life boats and rafts were put aboard.

She sailed from Woods Hole early in February, headed for the Caribbean. After a slow and difficult passage southward along the coast it became evident that the Caribbean was no longer a safe cruising ground, but the Gulf of Mexico was still clear of enemy submarines. Therefore during March and April a study was made of heat and water vapor exchange between the surface layer of the sea and the lower layer of the atmosphere in the central part of the Gulf of (*Continued on page 3*)

M. B. L. Calendar

FRIDAY, July 10, 8:00 P. M.
Lecture: "Nucleolus and Phylogeny," Dr. R. Ruggles Gates, University of London.

FRIDAY, July 17, 8:00 P. M.
Lecture: "Animal Luminescence," Dr. E. Newton Harvey, Princeton University.

TUESDAY, July 14, 8:00 P. M.
Seminar: Papers to be announced later.

WAR-TIME PROGRAM OF THE MARINE BIOLOGICAL LABORATORY

Dr. Charles Packard
Director,
The Marine Biological Laboratory

During the winter a flock of rumors about the sad fate of the Laboratory made its appearance. One report was that the M.B.L. had closed its doors permanently; another, that the Navy had taken over all of the buildings; a third, that since the Supply Department could not use its boats to collect material, marine research would have to be given up. But the investigators and students now at work in Woods Hole know that these and other wild rumors are false. The Laboratory is open as usual; living material collected along our shores and in the Sound is delivered daily, just as it always has been; the apparatus and chemical departments can supply the items usually asked for; the first Friday evening lecture has already been given, and the seminars will begin presently. The classes in Embryology, Physiology and Botany are in full swing. The "Mess," under the direction of Miss Downing, caters to our members as

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Photograph by Howard M. Wood, New Bedford, Mass.

AN AERIAL VIEW SHOWING THE LOCATION OF THE THREE BIOLOGICAL LABORATORIES IN WOODS HOLE

The U. S. Bureau of Fisheries Station in the left foreground, together with the land and buildings enclosed roughly by the large trees, has been taken over by the U. S. Navy.

usual, but not in the accustomed place. Meals are served at the Avery Hotel near the post office. Probably this change is the most obvious effect of the war on the Laboratory.

But other changes have occurred. Our numbers are much smaller than usual. Many investigators must teach at home during the summer and can come here only for short periods, if at all. Others are engaged elsewhere in research on problems connected with the war. Still others are undoubtedly kept away because their tires are worn, and they cannot get gas. At the present time there are 100 investigators registered, compared with 188 last year.

The classes are small, the total number of students in all courses this season being about 75 as against 125-130 in former years. The teaching staff is also small. Some of the instructors have had to drop out; their places have not been filled.

Several of our buildings have been taken over by the Navy and are now being repaired and altered for their new purpose. The "Mess" and Homestead, the Howes house, Rockefeller, Botany, and old Lecture Hall, together with the Apartment House are now enclosed within a high wire fence which also blocks off Water Street so that we can no longer visit the Fish Commission. The loss of the "Mess" threatened to be embarrassing, but fortunately the Avery Hotel became available and was taken by the Laboratory as a dining room and living quarters for the "Mess" employees. Those who for years have occupied the Apartment House were forced to give up their pleasant rooms and find places elsewhere, either in the Dormitory or in the village. They have taken these unwelcome dislocations in a good spirit.

Some important changes have occurred in the permanent staff. Dr. Pond, long in charge of the Chemical and Special Apparatus Department, is now engaged in research with the Navy in Washington; and Lester Boss has accepted a position at the Mellon Institute in Pittsburgh. At present there is no full time manager of this department. Dr. E. P. Little has taken over the care of the apparatus, and Mr. Kenneth Ballard, the Chemical Room. Both of these men made frequent visits to the Laboratory during the past winter, to prepare for the summer season. Under their direction these two departments are operating smoothly and efficiently.

During the winter, the Carnegie Corporation of New York gave the Library $25,000 to be used for the purchase of back sets and important works of reference. While present conditions prevent the Librarian, Mrs. Montgomery, from buying much wanted serials, we are assured of having funds with which to purchase them whenever they become available. Another welcome gift, from Mr. Atherton Seidell, is a complete microfilm outfit. This should be a boon to investigators who may be unable at present to come here to read, but who need references not available in their own libraries.

The process of adapting ourselves to changing conditions induced by the war has not been easy. Many problems involved in the taking over of the buildings by the Navy had to be settled quickly—that is, in the matter of hours, and the burden of making these decisions had to be borne largely by Mr. MacNaught and Mr. Larkin. That they decided wisely is evident. The difficulty of obtaining apparatus, chemicals, plumbing fixtures and other essentials is very real now and will probably grow greater with the passing months. Of great concern to those charged with running the affairs of the Laboratory is the sharply reduced income which has already forced many economies. These, and other problems which will undoubtedly arise, are troublesome but not insoluble. The present season bids fair to be successful, and we should look toward the future with confidence.

WORK OF THE *ATLANTIS* AND THE *ANTON DOHRN*

(Continued from Page 1)

Mexico. Over two long periods of several weeks each, very complete records were secured of the temperature distribution near the sea surface and of the meteorological conditions. No similar series of data has ever been secured in such detail and their analysis is yielding most interesting results.

On April 20th the *Atlantis* put in at Galveston, Texas, for supplies and within a few days enemy submarines appeared in force along the gulf coast. Insurance rates immediately went sky high. Since then the vessel has remained at Galveston, for her continued operation would be prohibitively expensive, not to mention the risks involved.

We have been able to continue operating the *Anton Dohrn* close to the coast. Whenever possible she makes port at night and by day ventures off shore no further than is absolutely necessary. Under such circumstances the sort of oceanography which one can hope to carry out is, to say the least, restricted. However, the waters near the shore in the past have been rather neglected by oceanographers and therefore her present coastwise cruises are not without significant results. Several times during recent months she has explored the inshore waters between Maine and South Carolina and we are in hopes of being able to continue these surveys during the summer.

THE APPLICATION OF THE ELECTRON MICROSCOPE TO BIOLOGY

Dr. Thomas F. Anderson

RCA Fellow of the National Research Council, Camden, N. J.

In applying the electron microscope to biology one must constantly bear in mind the various factors imposed on the worker by the inherent nature of the instrument on the one hand and the use of electrons as the radiation used for observation on the other. Each element of the light microscope has a counterpart in the electron microscope.[1] The lamp which serves as a source of light is replaced by an electron gun in which electrons emitted from a hot tungsten filament are accelerated by 60,000 volts to form a beam of electrons moving with a velocity almost equal to that of light; a magnetic condenser focuses this beam on the specimen; a magnetic objective lens forms an electron image of the specimen at a low magnification which is further increased by a projector lens corresponding to the eyepiece of the light microscope. The electrons which form this magnified image strike a fluorescent screen where their energy is converted into a light image which can be seen at a magnification which can be varied from 500 to 50,000 times. The white hot tungsten filament must, of course, be in a vacuum or it would be rapidly disintegrated by the gas molecules.

The points of difference between the electron microscope and the light microscope are principally due to the nature of the electrons as a source of radiation. The wave length of 60,000 volt electrons is only 0.05Å as compared to 5000Å for visible light. It is this short wave length which makes resolutions of 0.005μ in the electron microscope possible as compared with 0.2μ in the light microscope. Thus, instead of being refracted by broad surfaces of matter as light waves are, electrons interact principally with the *individual atoms* of which the matter is composed; indeed the interaction of electrons with atoms and molecules is so great that the entire path of the electrons in the microscope must be highly evacuated to prevent diffuse scattering and consequent blurring of the electron image by gas molecules. For this reason, too, the glass lenses of the light microscope must be replaced by the magnetic fields which act as lenses in the electron microscope. Also, the glass slides and cover slips used for mounting specimens in light microscopy must be replaced by thin films of collodion (100Å thick) which are supported on fine wire screen. One then observes the parts of the specimen which lie over the holes in this screen.

The specimen must, of course, be dry for insertion into the evacuated microscope. Electrons are then scattered by the atoms in the specimen and contrast in the image is obtained by the fact that thicker and denser parts of the specimen scatter more electrons and therefore appear dark, while thinner and less dense parts scatter fewer electrons and therefore appear light, irrespective of any pigments which may be present. For good resolution of detail inside a specimen, the specimen should be less than 0.2μ thick or it will all appear dark and blurred due to excessive scattering of electrons in the specimen.

Without doubt the two greatest experimental limitations of the microscope's application to biology are the conditions that the specimen must be dry and thin. In the first work with the microscope therefore, specimens were chosen which, because of their small size, automatically satisfied the requirement of thinness. Thus, in the study of viruses, the principal concern was the removal of salt from preparations, for small virus and protein molecules decompose on drying in the presence of salt. In most cases salt was removed from the viruses by centrifuging and resuspending the pellet obtained in distilled water. In this way, ultracentrifugally purified tobacco mosaic virus was found[2] to contain a predominating unit about 15mμ in width and 280 mμ in length. Since the particle length of this virus was significantly greater than those of two strains studied by other workers, it seems likely that strains of a virus may have different particle lengths. The electron micrographs of cucumber mosaic virus 3 and of its related strain, cucumber mosaic virus 4, were very similar, showed a marked amount of end-to-end aggregation, and indicated that the ultimate units were similar in size and shape to tobacco mosaic virus.[2] In the case of tomato bushy stunt virus, the micrographs showed spherical particles about 26 mμ in diameter, whereas with tobacco necrosis virus the results indicated that the particles were essentially spherical and about 20mμ in diameter.[2] Influenza virus also prepared in this manner was found[3] to consist of roughly spherical bodies only 10mμ in diameter.

Some viruses such as vaccinia agglutinate in the absence of salt. In this case one drop of the stock suspension of virus was placed on the collodion mount and removed a few seconds later by means of a fine capillary pipette. In this way, relatively few particles were brought into contact with the collodion membrane and those which became attached were rarely lost by subsequent manipulation but adhered firmly to the membrane. The surface of the membrane was then thoroughly washed by submersing it repeatedly in physiologi-

cal saline and subsequently in distilled water. Also, it was found that the effects of various agents on the structure of the virus could best be studied by applying the test materials directly to the films of active elementary bodies prepared as above described. Following treatment the films were again washed in saline solution and in water. The pictures obtained[4] indicated a remarkable regularity in the morphology of the elementary bodies, a brick-like shape with internal structure and some sort of limiting membrane.

Bacteriophages, or bacterial viruses, were identified and characterized[5] in much the same manner: the bacteria in nutrient were first adsorbed on to the collodion membrane and phage suspension added as a reagent. After various times of contact, the preparations were washed to remove soluble components and to stop the phage action and allowed to dry. In this manner anti-coli PC phage could be easily characterized as a tadpole shaped body with a "head" about 0.08μ in diameter, showing characteristic internal structure and a "tail" about 0.13μ long, while anti-coli P28 phage has a dense head about 50 mμ in diameter and a very thin tail; the progressive disintegration of the bacteria by phage action was followed and the liberation of phage particles from the lysing bacteria seemed to be indicated.

Bacteria are easily studied with the microscope for they can be mounted in a droplet in distilled water. In this way it was found[6] that bacteria of the genus *Bacillus* possess cell walls that are definite morphological structures which are solid enough to break along jagged lines when fractured by sonic vibrations. Typical polar granules appear[7] in electron micrographs of *C. diphtheriae* grown on blood agar, but when grown on potassium tellurite agar the tellurium is reduced to tellurium metal and needle-like crystals appear inside the cells which disappear on the addition of small amounts of bromine water. It is inferred, therefore, that the tellurium metal occurs in the form of needles inside the cells and that the tellurite ion is able to diffuse through the cell wall and is reduced with the production of tellurium metal within the cell boundaries.

In the field of immunology the specific reaction between tobacco mosaic virus and its antiserum, as well as the combination of antibodies with flagellar and somatic antigens, have been seen for the first time. The former study[8] revealed the irregular framework of thickened antigen molecules which makes up the antigen-antibody precipitate. The latter study[9] revealed that flagellae, too, become more conspicuous, thicker, less sharp and less uniform in outline and tend to cohere as a result of the deposition of homologous antibodies upon them.

In the field of genetics ordinary dry mounts of salivary gland chromosomes of *Sciara* and the lamp brush chromosomes of salamander eggs were studied, but were found to contain numerous artifacts due to drying. It was found[10] that these artifacts were avoided when the material was freeze-dried after mounting on the screen. Unfortunately the salivary gland chromosomes were too thick for study. On the other hand, the lampbrush chromosomes were sufficiently thin, and showed considerable detail.

Work with higher organisms was continued with investigations of a material, the chitin-like structures of insects, which presumably would be little affected by drying. Insect tracheae were dissected out, separated from cellular components which dissolve readily in distilled water, mounted upon collodion and allowed to dry. Many exceedingly fine structures were discovered[11] in the tracheae of various insects which seem to be more or less characteristic of the insect. The study of more massive structures too thick to be studied directly, was begun with an investigation[12] of insect cuticle which likewise would be little affected by drying. Here the material was imbedded in a carrot and cut free hand with a razor blade. A number of the many sections so obtained were found to be thin enough for study and revealed details of the molecular composition and porosity of the various layers of the cuticle.

Recently work has been begun on the sectioning of tissues for study in the electron microscope. One technique has proved successful;[13] after fixation, the material to be studied is embedded in a water miscible wax and sectioned with a microtome adjusted to feed the section to the knife at the rate of about 0.25μ per cut. The sections were then freed of wax by placing them in water, after which they were mounted on the screen and freeze-dried. Sections of striated muscle prepared in this way clearly showed the characteristic cross striations as well as longitudinal striations which may be related to the myofibrillae.

A special technique is usually required for each new type of material studied in the microscope, but the new technique is often as simple and frequently more simple than that required in light microscopy. However, the results obtained are well worth while and often of a startling nature. With resolutions verging on—and frequently attaining[14]—molecular dimensions, it is not surprising that investigations with the microscope have opened up whole new fields of biological research.

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THE EMBRYOLOGY COURSE AT WOODS HOLE IN 1942

Dr. Viktor Hamburger
Professor of Zoology, Washington University

The main purpose of this course is to bring students of biology in contact with the living, developing organism. In many marine forms the transformation of the egg cell into the complex organization of the larval or even the adult form is accomplished in the short span of a few days, under the eyes of the observer. The variety and wealth of invertebrate material, in particular, afford a unique opportunity for the study of fundamental processes of development such as fertilization, gastrulation, and morphogenesis on a broad comparative basis, and open new vistas to the student who has been trained in the traditional frog, chick, and pig embryology.

Descriptive embryology and observation of normal development are the backbone of the course. The modern trend towards experimental embryology will be strongly emphasized, however. Experiments have been done in the course for several years, and on different materials. This year, for the first time, a ten-day period will be set aside which will be devoted exclusively to experimental work. During the first part of this period classical experiments on Echinoderm eggs, such as artificial parthenogenesis, merogony, and exogastrulation will be done by the whole class under the direction of Dr. Rulon and Dr. Charles B. Metz. For the rest of the period the class will be divided into small groups of three to six students. Each group will do a series of experiments under the guidance of a counselor or an instructor. Dr. Barth will supervise the work of two groups, on regeneration in Coelenterates, and on respiration in eggs; Dr. Caswell Grave will direct experiments on the acceleration of metamorphosis in Ascidians. Other groups will do isolation experiments on Coelenterate and Ascidian eggs, hybridization and other studies on Teleost eggs, determinations of axial gradients and experimental modifications of the sea urchin development. The students will be encouraged to do collateral reading along the lines of their experimental work. On the last day, members of the different groups will report their results in two seminar sessions. Several evening seminars are planned for the informal discussion of such topics as embryonic induction, the gradient theory, genes in development. Special lectures on different aspects of experimental embryology by guests and staff members have been a valuable part of the course for many years. They will be continued and integrated into the experimental part.

The staff has been reduced considerably, due to the war emergency. Dr. W. W. Ballard resigned because the summer school program at Dartmouth College made it necessary for him to be in residence there. Dr. Daniel Pease is engaged in a defense project under the direction of Dr. E. N. Harvey at Princeton University. Dr. Pease made a special trip to Woods Hole to give two lectures on fertilization and to direct the laboratory work on this topic, but it was necessary for him to return to Princeton immediately afterwards. The staff consists now of only three members: Dr. Olin Rulon, assistant professor of zoology at Wayne University, Detroit; Dr. Ray Watterson, instructor of zoology at Dartmouth College, and the undersigned. Assistants are: Mr. P. A. Trinkaus and Dr. Charles B. Metz. The enrollment in the course is satisfactory; there are 24 students representing 18 institutions.

Viktor Hamburger

EMBRYOLOGY CLASS NOTES

Twenty-four embryology students arrived in the foggy dampness of Monday afternoon, June 15, 1942, unpacked microscopes in the laboratory, and applied vaseline vigorously. Of the eighteen colleges represented by the group, Mt. Holyoke, Smith, Russell Sage, Illinois, and Rochester each have more than one representative. Five members of the class were "repeaters" at Woods Hole, having previously indulged in the Invertebrate course.

On Tuesday morning, the Embryology course was opened by Dr. Hamburger who summarized the history of embryological study, pointed out the importance of marine forms in these investigations, and announced an innovation in the course for this year, namely, a special experimental period. Dr. Pease was then introduced and we were plunged into the battle of the sexes. After observing the explosive reactions set off by the attacking hordes of sperm, disappearance of subcortical granules, membrane elevation, and polar body eruption, we proceeded to a study of cleavage in teleosts under the direction of Dr. Hamburger. Fundulus eggs were fertilized and watched, the interest increasing with each new sign of life—heart beating, tail wagging, and the first wink of the eye. One skeptical member of the class fondly nurtured three eggs to the point of hatching, twelve days after fertilization, then lost all interest in the little wrigglers and put them into a laboratory aquarium where they undoubtedly became food for larger fish.

Dr. Hamburger, on the second day of teleost study, brought the class down on its knees before their tilted microscopes to view pelagic cunner eggs. He then chuckled as he gazed about the room and proclaimed it a rare sight.

At the beginning of the second week, we took up the subject of squid embryology, much to the blushing embarrassment of the young squid with their newly acquired chromatophores. Wednesday morning Dr. Hamburger gave a superb lecture on induction. We had been forewarned by "those who knew" that it would be a classic, and we were not disappointed.

Since the squid egg supplies were low, the course was then turned over to Dr. Watterson. The latter claimed on the sly that he was unprepared for this sudden assumption of responsibility, but he proceeded to give us two lectures, on coelenterates and tunicates, which fairly overwhelmed us with the vast amount of material that was so clearly condensed and presented in so short a time. We are still wondering what Dr. Watterson would have given had he been prepared! For a day and a half we observed polyps and medusae from colonies on the shells of hermit crabs, and then for another day watched Styela eggs with their changing yellow crescents. By far the outstanding experiment of this period, however, was an evening experiment, conducted with much hilarity, in which certain helpless hermit crabs were deprived of their shells and offered shells of the wrong size in return!

On Friday and Saturday of that week and Monday and Tuesday of this week, Woods Hole's favorite sea-urchin again came into the spotlight as we commenced the study of echinoderms under Dr. Rulon.

In addition to the regular morning lectures, a series of weekly evening seminars has been instituted. Dr. Hamburger conducted the first on Wednesday evening, June 24th, opening it with a continuation of his lecture on induction. In the forum which followed, he struggled in vain to keep the discussion centered around gastrulation.

With the lifting of the fog which chilled us for the first four days, the class became divided into two squads, one to go to the beach early each afternoon, and one to remain to keep on eye on the growing colonies. At approximately four o'clock every day occurred the changing of the guard.

Saturday night in the small town found the embryologists in ties and heels, meeting the rest of the M.B.L. community in a clubhouse newly trimmed with gay black-out curtains. Conversational openers ranged from, "Where are you from?" to "Does that bugler wake you up at five in the morning, too?" After the Paul Jones, nobly led by our assistant, "the Bishop", leap year practices became the vogue, though two years off schedule. The first M.B.L. mixer of the season went off with a punch.

Innovation number three in the embryology course was experienced by a small group of students who were the first to go out to the fishing traps. They struggled out of bed at the sound of reveille and embarked on the *Sagitta* at six o'clock, carrying two buckets of Fundulus to be cross-fertilized with mackeral out at the traps. The *Sagitta* rolled and rocked till the fish were lurching about their buckets in a sea-sick fashion, and on the return trip the fertilized eggs became so scrambled by the heaving that startling results are expected from the experiment. Otherwise the trip was a success.

J. S. and E. C.

THE PHYSIOLOGY COURSE AT THE M.B.L. IN 1942

Staff of the Physiology Course

The physiology course is being carried on as usual during the first war session of the laboratory, but with reduced staff and student registration. In the absence of Dr. Arthur K. Parpart of Princeton, Dr. Rudolf T. Kempton of Vassar is temporarily in charge of the course. Dr. Parpart and Dr. Robert Ballentine have both been prevented by war work from participating in the course this summer.

As is the custom, during the first part of the course the students study a series of topics, and during the latter part work on individual problems. During the first two weeks Dr. Ferdinand Sichel of the University of Vermont has presented the physiology of nervous and contractile systems, and Dr. Kempton has presented micrurgy and topics in excretion. The students are now studying cellular respiration with Dr. Kenneth Fisher of the University of Toronto and the biological effects of radiation with Dr. Arthur Giese of Stanford University. This last type of work is being introduced for the first time this year.

Several investigators have been guest lecturers, and others will address the group from time to time. Those who have already lectured include William R. Amberson, George Wald, Benjamin Zweifach, Valy Menkin and D. E. S. Brown. Visitors are invited to all lectures.

PHYSIOLOGY CLASS NOTES

Those who have recently seen the assorted teeth scattered about, instantly realized that the physiology class had begun. Calibrations with mercury have a distinct deleterious effect.

This well-balanced group numbers five and a half; four females, one George, and Nat, who commutes to and from his draft board. During the last couple of weeks a perfectly incredible amount of serious work has been accomplished. The class is attempting to establish the truth of the equation: The number of students multiplied by the total average work done in previous years is equal to a constant.

Faultless techniques have been developed, both in the laboratory and at Boulder Beach—the former naturally taking precedence, (perish the thought). We now have several expert micromanipulators of floating frog kidneys, as well as micromanipulators of physics problems. A new philosophical approach to the work has appeared; the essence of the pleasure we get from our problems is derived from the setting up of the apparatus for hours and hours, while the brief observations constitute an anticlimax.

But to be serious for a moment, we have had a really fine series of lectures. Dr. Kempton opened the course by speaking on the kidney; Dr. Sichel followed with lectures on excitation; Dr. Fisher spoke on cell respiration, and Dr. Giese is now lecturing on photobiology.

So far no one has so much as given a thought to planning a picnic. We enjoy our picnics vicariously by gorging ourselves with food in the lab. There are countless quantities of cherry pits hurled about during the day, while in the evening there are hamburgers, hotdogs, coffee, and beer in what Ester so euphemistically calls "The Village." It is rumored that there are individuals about who have been walking around for weeks without seeing anyone else. What a lively town!

July 1 *Anonymous*

BOTANY CLASS NOTES

One cell and then another—that is an alga, Goucher style. On Tuesday, June 23, 1942, Botany Row started off with a bang supplied by the oceanographic depth bombs. We could feel the Old Main Building swaying beneath us, but our intrepid Dr. Taylor maintained his equilibrium and continued operations from his soap box. Aided by his soothing boardside manner, we were soon initiated into the mysteries of heterocysts, akinetes, and gonadanguia.

The first week was consumed in an exhaustive study of the morphology, distribution, and economic importance of blue-green algae. Thursday Dr. Croasdale and Dr. Taylor led us on a fast-pace trip to and through the fresh water ponds of Cedar Swamp and vicinity. This trip netted us some thirty-five genera identified in the course of

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"The Collecting Net" was entered as second-class matter July 11, 1935, at the Post Office at Woods Hole, Mass., under the Act of March 3, 1879, and was re-entered on July 23, 1938. It is devoted to the scientific work at marine biological laboratories. It is published bi-weekly between July 1 and September 1 from Woods Hole, and is printed at The Darwin Press, New Bedford, Mass. Its editorial offices are situated in Woods Hole, Mass. Single copies, 30c; subscription, $1.00.

The A. B. C. of Woods Hole for 1942

Eastern War Time—Bold Type Indicates P. M.

POST OFFICE

	Week Days	Sundays
Mail Arrives	7:00, 11:00, **7:30**	11:00
Mail Closes	6:30, 9:45, **5:00**	**5:00**
Station Open	7:30 to **8:00**	10:30 to **5:00**
Window Service	7:30 to **6:00**	.....

TELEGRAPH OFFICE

Weekdays
8:00 to **9:00**

Sundays	Holidays
9:00 to 11:00	8:00 to 10:00
4:00 to **6:00**	4:00 to **6:00**

LIBRARY HOURS

Wednesdays and Saturdays
3:00 to **5:00**
7:00 to **9:00**
Until Sept. 15

RELIGIOUS SERVICES

Church of the Messiah (Episcopal)
Sundays: 8:00, Holy Communion; 11:00, Morning Prayer.
First Sunday in each month: 10:00, Holy Communion.

Methodist Episcopal Church
Worship, 11:00. Church School, 9:45.

St. Joseph's Roman Catholic Church
Mass: Sundays, 6:45, 9:30.
Weekdays, 7:00.

TRAIN SCHEDULE*

	Weekdays	Weekdays	Ex. Sat. & Sun.	Weekdays	Sundays	Sundays
Woods Hole	7:06	10:15	8:35[a]	**5:45**	**5:50**	**7:55**[b]
Boston	9:15	12:35	10:40	**8:05**	**8:00**	**9:55**

	Weekdays	Sundays	Saturdays	Weekdays	Ex. Sat. & Sun.	Weekdays
Boston	8:20[a]	8:15[b]	**12:25**	**1:15**	**4:00**[a]	**5:00**
Woods Hole	10:45	10:30	**2:30**	**3:35**	**6:00**	**7:20**

* All trains stop at Falmouth. [a] Will not run Sept. 7. [b] Also runs Monday, Sept. 7.

BOAT SCHEDULE

	Week Days					Sundays			
Lv. New Bedford	9:30[a]	11:15[b]	**2:15**	**7:30**[x]	....	9:15[g]	11:15[h]	**2:15**	**7:45**[y]
Lv. Woods Hole	10:50[a]	**12:30**[b]	**3:45**	[e]**8:45**[x]	**9:30**[f]	10:30[g]	**12:30**[h]	**3:45**	**9:00**[y]
Lv. Oak Bluffs	11:40[a]	**1:15**[b]	**4:30**	....	**10:15**[f]	11:15[g]	**1:15**[h]	**4:30**	....
Due Vine. Haven	*	*	*	[e]**9:30**[x]	....	*	*	*	**9:45**[y]
Due Edgartown	*	*	*	....	....	*	*	*	....
Due Nantucket	**2:00**[a]	**3:30**[b]	**6:45**	....	**12:15**[f]	**1:30**[g]	**3:30**[h]	**6:45**	....

	Week Days					Sundays			
Lv. Nantucket	....	6:45	**2:30**[a]	**4:30**[b]	**7:00**[f]	....	6:45	**2:00**[g]	**4:30**[h]
Lv. Edgartown	....	*	*	*	....	....	*	*	*
Lv. Vine. Haven	6:10	*	*	*	....	6:10	*	*	*
Lv. Oak Bluffs	....	9:00	**4:30**[a]	**6:45**[b]	....	....	9:00	**4:00**[g]	**6:45**[h]
Lv. Woods Hole	6:55	10:00	[z]**5:30**[a]	**7:30**[b]	**8:45**[f]	6:55	10:00	**5:00**[g]	**7:30**[h]
Due New Bedford	8:15	11:15	**6:45**[a]	**8:45**[b]	....	8:15	11:15	**6:30**[g]	**8:45**[h]

* By connecting Motor Coach.
[a] Will not run Monday, Sept. 7.
[b] Discontinued after Sept. 8.
[e] On Fridays June 26, Sept. 11 and 18 leave Woods Hole 9:45 P. M. due Vineyard Haven 10:30 P. M.
[f] Fridays only July 3 to Sept. 4 incl.
[g] Also runs Monday, Sept. 7.
[h] Discontinued after Sept. 6.
[x] Will not run Sept. 7. [y] Also runs Sept. 7.
[z] Bus leaves Woods Hole 5:30 P. M., due Prov. 7:45 P. M., connects with New York train.

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Judy Woodring and Jane Woodring.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

THE M.B.L. CLUB IN 1942

The M.B.L. Club, which serves as a general social meeting place for the scientific workers and their families at the Woods Hole laboratories, is now beginning its 29th season.

This year the Clubhouse was officially opened on June 20th with an enjoyable and traditional "Mixer". Although the lights from the Clubhouse had to be "dimmed out" by new curtains and shades to reduce skyglow according to U. S. Army regulations, nevertheless a gay spirit prevailed during the Mixer and the dancing which followed.

The total attendance at the M.B.L. and W.H.O.I. is smaller this season, but we believe that the M.B.L. Clubhouse is being used more than before because of the limitations on travel due to the rationing of gasoline and the scarcity of tires.

For those who this year have joined the Woods Hole scientific community for the first time and do not know about the club, we should like to tell you that the M.B.L. Clubhouse offers comfortable chairs, a fine view of the harbor, a variety of magazines and papers to read, a chance a relax or play bridge, ping-pong, chess and other games. Each Saturday evening there is a gay informal dance, and the Monday evening weekly concerts of classical music are attended by many members.

The Club is always open to all students and workers at the Woods Hole laboratories and their families on payment of dues. Dues for regular membership for the season are $1.50. Students enrolled in one of the courses may join for the duration of the course for $1.00.

The M.B.L. Club invites you to membership, and needs the support of all its friends. You may join by paying your dues to Miss Polly Crowell in the main office of the M.B.L.; to the hostess at the clubhouse; or to the treasurer, Elsa Keil Sichel in Old Main Building (Room 4).

Elsa Keil Sichel, *Sec.-Treas.*

THE CHILDREN'S SCHOOL OF SCIENCE

Monday was the registration day for the Children's School of Science and Junior Laboratory. Forty-two children enrolled with more expected during the week. After the registration hour Mrs. Lower showed colored slides dealing particularly with birds, which were thoroughly enjoyed by the children.

At the semi-annual meeting of parents and friends of the Association held Monday afternoon the teachers were introduced, and each gave a brief outline of her courses. Miss Helen Smith has returned as head of staff and Mrs. George Lower as teacher of the younger groups. The intermediate group will be taught by Miss Pauline Sullivan, who is new this year, coming from Choate School in Brookline.

Miss Smith will give her marine ecology course in which specimens are collected on field trips and identified and preserved. Miss Smith will also give the course in elementary biology with experiments and dissections of interesting forms. Mrs. Lower will be teaching full-time this year, giving the introductory course for the younger group, which will be a general course in which studies will be made of animals and plants, their associations, adaptations and habits. The Water Life course will also be given by Mrs. Lower; this will place emphasis of the common animals and plants of both fresh and salt water, with special reference to the features fitting the organism to its environment. The intermediate science course with Miss Sullivan will be a transition course supplementing the early courses and preparing for the advanced courses. The Junior Laboratory will make studies not easily undertaken in winter classes with preparation of microscope slides, the culturing of simple animals and experiments done by the individual young people.

Mrs. William Randolph Taylor, President

CURRENTS IN THE HOLE

At the following hours (Eastern War Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
July 8	12:43	12:55
July 9	1:36	1:44
July 10	2:24	2:32
July 11	3:08	3:15
July 12	3:50	3:58
July 13	4:30	4:39
July 14	5:09	5:19
July 15	5:50	6:01
July 16	6:30	6:44
July 17	7:11	7:28
July 18	7:55	8:15
July 19	8:40	9:06
July 20	9:30	9:59

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The first Friday evening lecture was presented on June 26th; Dr. Michael Heidelberger of Columbia University spoke on "Biological Aspects of Immunity and Complement Action." The second one was given by Dr. Donald R. Griffin of Harvard University who spoke on "Echo Sounding by Flying Bats." Dr. E. Newton Harvey, who was to have given the third lecture on July 10 will be prevented from doing so by war conferences; he will, however, speak on July 17.

DR. AND MRS. CHARLES PACKARD will be at home to members of the M.B.L. on Sunday, July 12, from 4:30 to 6:00 o'clock.

The 1942 Chemical Industry Medal, one of the highest honors of American applied chemistry, has been voted to Dr. H. E. Howe, now at the Laboratory, who is editor of *Industrial and Engineering Chemistry*. Formal presentation of the medal will be made in New York on November 6.

DR. S. A. WAKSMAN, microbiologist at the New Jersey Agricultural Experiment Station and bacteriologist at the Woods Hole Oceanographic Institution, was elected to the National Academy of Sciences early this spring.

DR. DONALD DUNCAN, associate professor of anatomy of the Faculty of Medicine at the University of Texas, has been appointed professor and head of the Department of Anatomy at the University of Buffalo School of Medicine.

DR. H. BURR STEINBACH, associate professor of zoology at Washington University in St. Louis, succeeds Professor Alfred C. Redfield as Managing Editor of *The Biological Bulletin*.

MISS EMILIA VICARI, formerly research assistant to the late Dr. Charles Stockard, has received one of the Finney Howell Research Fellowships to work at the Roccoe B. Jackson Memorial Laboratory at Bar Harbor.

DR. VANCE TARTER, instructor of zoology at the University of Vermont, has been drafted into the United States Army and will therefore not take part in teaching the invertebrate zoology course at the M.B.L. as previously planned.

DICK HARVEY, the son of Dr. and Mrs. E. Newton Harvey, completed his junior year at Princeton, and after visiting Woods Hole, has entered Cornell University Medical School.

DR. SEARS CROWELL, assistant professor of zoology at Miami University (Oxford, Ohio), has been visiting Woods Hole with his oldest daughter (2½ years!).

Among the investigators who have been working at the Laboratory and who have already left Woods Hole are: Dr. E. A. Wolf, Mr. Charles Wurtz, Miss Maryon Dytche, Dr. Valy Menkin, Dr. I. C. Plough, and Dr. and Mrs. F. J. Sichel.

DR. ERIC PONDER, until recently director of the Biological Laboratory at Cold Spring Harbor, is visiting Woods Hole for several days.

DR. FRANK BLAIR HANSON has completed a visit of two weeks at Woods Hole. He hopes to be able to return late in August.

DR. H. S. HOPKINS, associate professor of physiology at the College of Dentistry at New York University, just completed a two weeks' visit at Woods Hole and has returned to teach physiology at the College.

DR. GEORGE WALD and family were in Woods Hole for two weeks, arriving on June 10.

DR. C. LLOYD CLAFF visited Woods Hole on Saturday. He is working in the Department of Experimental Surgery at Harvard University Medical School until July 25 when he plans to return to Woods Hole for the rest of the summer. Dr. Claff is President of the M.B.L. Club.

BUREAU OF FISHERIES STATION

Buildings and grounds of the U. S. Fish and Wildlife Service at Woods Hole (the former Bureau of Fisheries) are now occupied by the U. S. Navy for the duration of the war. At the closing of the season last year the functions of this oldest institution at Woods Hole were discontinued. During the winter the library, movable laboratory equipment and supplies were removed, and thanks to the administration of the M.B.L., safely stored in the main brick building. The boat, *Phalarope II*, has been assigned to the Fishery Biological Laboratory at Milford, Connecticut. Extensive alterations and improvements have been made both in the laboratory and in the residence for the needs of the Navy. The personnel employed in the hatchery has been retired or transferred to other stations.

After the war the station will be returned again to the U. S. Fish and Wildlife Service. No plans have been made at present regarding the future operation of the fisheries laboratory, hatchery and public aquarium. All necessary steps have been taken, however, to safeguard all essential equipment so that activities of the institution may be resumed as soon as normal and peaceful life of the country is restored. —*Dr. Paul S. Galtsoff*

DIRECTORY FOR 1942

KEY

Laboratories		Residence	
Brick Building	Br	Dormitory	D
Old Main Building	OM	Drew House	Dr
Supply Dept.	S	Kidder	K
		Whitman	W

MARINE BIOLOGICAL LABORATORY

THE SCIENTIFIC STAFF

ZOOLOGY

Consultants

Bissonnette, T. H. prof. Biol. Trinity.
Woodruff, L. L. prof. proto. Yale.

Instructors

Burkenroad, M. D. asst. curator. Bingham Oceanographic Found. (Yale).
Gilbert P. W. instr. zool. Cornell.
Jones, E. R. prof. biol. William & Mary.
MacGinitie, G. E. director. Kerckhoff Marine Lab. (Cal. Inst. Tech.).
Martin, W. E. assoc. prof. zool. DePauw.
Mattox, N. T. asst. prof. zool. Miami.
Smith, R. I. Biol. Lab. (Harvard).
Waterman, A. J. assoc. prof. biol. Williams. in charge.

EMBRYOLOGY

Consultants

Barth, L. G. assoc. prof. zool. Columbia.
Goodrich, H. B. prof. biol. Wesleyan. (Aug.).

Instructors

Hamburger, V. prof. zool. Washington (St. Louis). in charge.
Rulon, O. asst. prof. zool. Wayne (Detroit).
Watterson, R. L. instr. anat. & emb. Dartmouth.

PHYSIOLOGY

Consultants

Amberson, W. R. prof. phys. Maryland Med. (left).
Garrey, W. E. prof. phys. Vanderbilt Med. (Aug.).
Jacobs, M. H. prof. phys. Pennsylvania.

Instructors

Fisher, K. C. asst. prof. biol. Toronto.
Giese, A. C. assoc. prof. biol. Stanford.
Kempton, R. T. prof. zool. Vassar. in charge.
Sichel, F. J. M. asst. prof. phys. Vermont Med.

BOTANY

Consultant

Brooks, S. C. prof. zool. California.

Instructors

Croasdale, Hannah tech. asst. zool. Dartmouth.
Taylor, W. R. prof. bot. Michigan. in charge.

INVESTIGATORS

Addison, W. H. F. prof. hist. & emb. Pennsylvania. Br 113.
Amberson, W. R. prof. phys. Maryland Med. (Aug. 1).
Anderson, T. F. RCA fel. Nat. Res. Council. Br 311.
Andrew, W. asst. prof. hist. & emb. Baylor Med. Br 217j. (Aug. 1).
Baker, H. B. prof. zool. Pennsylvania. Br 221.
Ball, E. Nat. Res. fel. bot. Yale. (July 20).
Barth, L. G. asst. prof. zool. Columbia. Br 228.
Berger, C. A. prof. cyt. & genetics. Fordham. Br 225.
Blum, J. L. instr. biol. Canisius (Buffalo). OM 44.
Bodansky, O. res. worker pharmacol. Cornell Med.
Botsford, Frances E. assoc. prof. zool. Connecticut College. Br 122d.
Brooks, Matilda N. res. assoc. biol. California. Br 322.
Brooks, S. C. prof. zool. California. Br 322.
Brownell, Katharine A. res. assoc. phys. Ohio State. Br 111.
Budington, R. A. prof. zool. Oberlin. Br 218.
Butler, Mary Pennsylvania. Br 205.
Calkins, G. N. prof. zool. Columbia. Br 331.
Cannan, R. K. prof. chem. New York Med. Br 206.
Chambers, R. prof. biol. New York. Br 317.
Cheney, R. H. prof. biol. Long Island. Br 118.
Claff, C. L. res. assoc. biol. Brown. (July 15).
Clark, A. M. grad. zool. Pennsylvania. OM 46.
Clark, E. R. prof. anat. Pennsylvania. Br 117.
Clark, Eleanor L. res. asst. anat. Pennsylvania Med. Br 117.
Clowes, G. H. A. res. dir. Lilly Res. Lab. Br 319.
Cole, K. S. assoc. prof. phys. Columbia, Br 115.
Copeland, M. prof. biol. Bowdoin. Br 334.
Croasdale, Hannah asst. zool. Dartmouth. OM 21.
Daniel, Paul (Sister) instr. bot. Chestnut Hill (Pa.). Br 217i.
Delbrück, M. instr. physics. Vanderbilt. Br 312. (July 15).
Dreyer, N. B. assoc. prof. pharmacol. Long Island Med. Br 315.
Dytche, Maryon M. grad. asst. biol. Pittsburgh. (left).
Eakin, R. M. asst. prof. zool. California. Br 315.
Evans, T. C. res. asst. prof. radiol. Iowa State. Br 340.
Failla, G. physicist. Memorial Hospital. Br 306.
Ferguson, F. P. asst. zool. Minnesota. Br 210.
Frisch, J. A. prof. biol. Canisius College (Buffalo). OM 44.
Gabriel, M. lect. zool. Columbia. Br 314.
Galtsoff, P. S. biol. U. S. B. F. Br 332.
Garrey, W. E. prof. phys. Vanderbilt Med. Br 215. (Aug.).
Garzoli, R. F. grad. zool. California. Br 322.
Gates, R. R. prof. bot. London. Br 303.
Giese, A. C. assoc. prof. biol. Stanford. OM Base.
Glancy, Ethel tutor biol. Queens College. Br 217g.
Glaser, O. prof. biol. Amherst. Br 330.
Grave, B. H. prof. zool. De Pauw. OM 45. (Aug.).
Grave, C. prof. zool. Washington (St. Louis). Br 327.
Grosch, D. S. asst. instr. zool. Pennsylvania. OM 46.
Hamburger, V. prof. zool. Washington (St. Louis). Br 318.
Hartman, F. A. prof. phys. Ohio State. Br 111.
Harvey, Ethel B. indep. invest. biol. Princeton. Br 116.

Harvey, E. N. prof. phys. Princeton. Br 116.
Heidenthal, Gertrude res. asst. Pennsylvania. OM 41.
Heilbrunn, L. V. assoc. prof. zool. Pennsylvania. Br 220.
Hendley, C. D. asst. biophysics. Columbia. Br 314. (July 15).
Henry, R. J. Pennsylvania Med. OM 1.
Hill, S. E. prof. biol. Russell Sage (N. Y.). Br 222.
Hinchey, M. Catherine instr. biol. Temple. Br 217.
Hohwieler, H. J. grad. asst. zool. Washington (St. Louis). Br 207.
Howe, H. E. ed. Industrial & Eng. Chem. Br 203.
Hyman, C. res. asst. biol. New York. Br 334.
Jacobs, M. H. prof. phys. Pennsylvania. Br 205.
Jaeger, Lucena grad. zool. Columbia. Br 314.
Johlin, J. M. assoc. prof. biochem. Vanderbilt Med. Br 123.
Keltch, Anna K. res. chem. Lilly Res. Lab. Br 319.
Kempton, R. T. prof. zool. Vassar. OM 3.
Kielich, E. R. grad. asst. biol. Canisius (Buffalo).
Krahl, M. E. res. chem. Lilly Res. Lab. Br 333.
Krugelis, Edith J. res. asst. zool. Columbia. Br 324.
Lee, R. fellowship. Br 339.
LeFever, P. G. res. asst. zool. Pennsylpania. OM Base.
Levine, P. bac. Newark Beth Israel Hosp.
Lillie, F. R. prof. emb. Chicago. Br 101.
Lillie, R. S. prof. phys. Chicago. Br 326.
Little, E. P. instr. science. Phillips Exeter. Br 3.
Lowenstein, B. E. res. assoc. biol. New York. Br 328-A.
Luria, S. E. res. asst. bact. Columbia Med. Br 312. (July 15).
Marsland, D. A. asst. prof. biol. New York. Br 343.
Mast, S. O. prof. zool. Hopkins. Br 329.
Mathews, A. P. prof. biochem. Cincinnati. Br 341.
Mavor, J. W. prof. biol. Union. Br 303.
Menkin, V. asst. prof. path. Harvard Med. (left).
Metz, C. B. instr. biol. Wesleyan, Conn. OM 41.
Metz, C. W. prof. zool. Pennsylvania. Br 305.
Meyerhof, O. prof. biochem. Pennsylvania. Lib.
Miriam Elizabeth (Sister) assoc. prof. biol. Chestnut Hill (Pa.). Br 217h.
Mitchell, P. H. prof. biol. Brown. Lib.
Molter, J. A. grad. zool. Pennsylvania. OM Base.
Moog, Florence grad. zool. Columbia. Br 314.
Morgan, Lillian V. Br 320.
Morgan, T. H. prof. biol. California Inst. Tech. Br 320.
Nabrit, S. M. prof. biol. Atlanta. Br 126.
Nelson, L. Pennsylvania. OM Base.
Packard, C. asst. prof. cancer res. Columbia. Br 102.
Phillips, C. asst. anat. Morehouse (Georgia). Br 126.
Pierson, Bernice F. instr. biol. National Park (Md.). Br 217b. (Aug.).
Plough, H. H. prof. biol. Amherst. Br 223. (left).
Pollister, A. W. assoc. prof. zool. Columbia. Br 324.
Recknagel, R. O. instr. zool. Pennsylvania. OM Base.
Richards, A. G. instr. zool. Pennsylvania. Br 310.
Ris, H. Yale University. Br 314.
Rugh, R. assoc. prof. biol. New York. Br 343.
Rulon, O. asst. prof. biol. Wayne. Br 122-A.
Schallek, W. B. grad. biol. Harvard. Br 315.
Schaeffer, A. A. prof. biol. Temple. Br 214.
Scott, Florence M. prof. zool. Fordham. Br 225. (Aug. 15).
Shaw, Myrtle senior bact. N. Y. State Dept. Health. Br 122-B.
Shelanski, L. grad. zool. Pennsylvania. OM Base.
Shelden, F. F. instr. phys. Ohio State. Br 111.
Sichel, Elsa Keil head of science Vermont State Normal. OM 4. (left).
Sichel, F. J. asst. prof. phys. Vt. Med. OM 4. (left).
Slifer, Eleanor H. asst. prof. zool. Iowa. Br 217a.
Smelser, G. K. asst. prof. anat. Columbia. Br 114.
Southwick, Mildred D. instr. bot. Vassar. (Aug. 3).
Spiegelman, S. grad. asst. zool. Washington. Br 313.
Steinbach, H. B. assoc. prof. zool. Washington (St. Louis). Br 313.
Stevens, Katharine Vassar. OM 2.
Stewart, Dorothy R. assoc. prof. biol. Skidmore. Br 205.
Stiles, C. A. prof. biol. Coe College (Ia.). Lib.
Taylor, Harriett E. grad. asst. zool. Columbia. Br 314.
Taylor, W. R. prof. bot. Michigan. OM 21.
Trinkaus, J. P. grad. asst. zool. Hopkins. OM 41.
Tuttle, Connie grad. phys. Mt. Holyoke. OM 3.
von Sallmann, L. J. asst. prof. opthal. Columbia Med. Br 114. (July 15).
Waterman, A. J. assoc. prof. biol. Williams. OM 28.
Watterson, R. L. instr. anat. & emb. Dartmouth. OM 40.
Wenrich, D. H. prof. zool. Pennsylvania. Br 220. (Aug. 1).
Wenstrup, E. J. prof. biol. Fordham. Br 225.
Whiting, P. W. assoc. prof. zool. Pennsylvania. OM 46.
Wiercinski, F. J. res. asst. zool. Pennsylvania. Br 110.
Wilbur, K. M. instr. zool. Ohio State. Br 342.
Wilson, W. L. grad. asst. zool. Pennsylvania. OM Base.
Wolf, E. A. assoc. prof. biol. Pittsburgh. (left).
Wolf, Opal M. assoc. prof. Goucher. Br 122-C.
Woodruff, L. L. prof. proto. Yale. Br 323.
Wrinch, Dorothy prof. biol. Amherst. Br 335.
Wurtz, C. B. grad. asst. biol. Pittsburgh. (left).
Zweifach, B. W. res. assoc. biol. New York. Br 328.

STUDENTS

Arrowsmith, Jr. H. N. Hopkins. bot.
Beardsley, Margaret grad. zool. Smith. emb. W-d.
Boss, Mary B. Goucher. emb.
Behnke, Jane Wellesley. bot.
Buggs, C. W. prof. biol. Dillard (New Orleans). emb.
Booth, Mary L. Smith. bot. W-a.
Carpenter, Elizabeth grad. asst. zool. Mt. Holyoke. emb. W-e.
Christiansen, Gertrude M. grad. asst. zool. Wellesley. phys. W-e.
Churchill, W. S. grad. asst. zool. Illinois. emb.
Cole, Edith asst. biol. Wesleyan. emb.
Deid, S. G. grad. biol. Wesleyan. emb. K-5.
Dunn, Barbara grad. asst. zool. Wellesley. emb. W-a.
Elias, Catherine grad. zool. Connecticut (Women). emb.
Foster, J. J. grad. asst. biol. Amherst. emb. Dr 2.
Gajdusek, D. C. Rochester. emb. Dr 3.
Geisler, F. S. grad. biol. Catholic. emb.
Hardenbergh, Ester grad. zool. Mt. Holyoke. phys. W-f.
Hitchcook, Margaret V. Goucher. bot.
Kingsley, Eunice L. asst. prof. bot. Kansas State.
Larson, Virginia grad. asst. phys. Vassar. phys. W-b.
Littrell, Jae L. grad. asst. zool. Illinois. emb. K-10.
Low, Eva M. Radcliffe. phys. W-i.
Memhard, A. R. Connecticut. emb.
Newfang, Dorothy M. grad. vital econ. Rochester. emb. K-2.
Nickerson, M. grad. asst. biol. Hopkins. emb. K-7.
Osterman, G. B. instr. physiol. Washington & Jefferson. phys.
Paull, J. J. Washington & Jefferson. bot. K-7.
Philbrick, Madeline G. Russell Sage. emb.
Poindexter, Joan Smith. emb. W-d.
Poker, N. grad. biol. Brooklyn. phys. K-6.
Prodell, J. H. Drew. emb. Dr.

Reyer, R. W. grad. zool. Cornell. emb.
Richardson, E. A. grad. asst. biol. Rutgers. bot. Dr.
Seitner, Margaret M. grad. biol. Hunter. emb. W-b.
Senyard, Juanita grad. asst. zool. Mt. Holyoke. emb. W-e.
Shea, S. E. asst. biol. Canisius (Buffalo). emb.
Wood, Marcia Russell Sage. emb. W-g.
Young, Margaret E. grad. asst. bot. Wellesley. bot.

OFFICE OF ADMINISTRATION

Allen, Glade F. secretary.
Crowell, Polly L. assistant to business manager.
MacNaught, F. M. business manager.
Packard, C. director.
Sherburne, Francese secretary. W-i.

LIBRARY

Lawrence, Deborah secretary.
Montgomery, Priscilla B. librarian.
Rohan, Mary A. assistant.
Thombs, S. Mabell assistant.

MUSEUM

Gray, G. M. curator emeritus.

DEPARTMENT OF CHEMICAL SUPPLIES AND SCIENTIFIC APPARATUS

Chemical Room

Ballard K. C. teach. sci. Lawrence H. S. (Falmouth).
Hathaway, Madelyn.
Hatch, M. H. Brown.

Apparatus and Technical Service

Graham, J. D. Pennsylvania. glass blower. Br 22.
Lefevre, Dorothy E. secretary. Br 1.
Liljestrand, R. S. Br 3.
Little, E. P. instr. Phillips Exeter. Br 1.

EXPERIMENTAL RADIOLOGY

Failla, G. Memorial Hospital. Br 307-8.
Hyde, L. R. Phillips Exeter. Br 307-8.

MAINTENANCE

Cannon, F. janitor.
Hemenway, W. C. carpenter.
Kahler, R. S. assistant.
Larkin, T. W. superintendent. Br 7.
Tawell, T. E. head janitor.
Thompson, J. janitor.
Travis, R. F. mail.
Trinkaus, W. janitor.

SUPPLY DEPARTMENT

Bulmer, Gladys teach. H. S. (Philadelphia). collector.
Crowell, Ruth S. secretary.
Emerson, R. Harvard. collector.
Goffin, R. collector.
Gray, M. B. collector.
Harman, Guy secretary.
Hilton, A. M. collector.
Hopkins, A. Newton collector.
Kahler, W. E. collector.
Leathers, A. W. head shipper.
Lehy, G. collector.
Leonard, E. collector.
McInnis, J. manager.
Powers, W. collector.
Wamsley, F. W. supervisor schools (Charleston). preparator.
Young, E. Worcester Acad. collector.

THE BIOLOGICAL BULLETIN

Drew, Barbara editorial assistant. Br 120.
Steinbach, H. B. managing editor. Br 120.

THE JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMIISTRY

Anderson, Stella B. secretary. Br 203.
Gordon, Gladys secretary. Br 203.
Howe, H. E. editor. Br 203.
Martenet, Dorothy secretary. Br 203.
Newton, Helen K. manuscript editor. Br 203.
Parkinson, Nellie assistant to editor. Br 203.
Rowand, Dorothy E. secretary. Br 203.

THE COLLECTING NET

Cattell, W. managing editor. Scientific Monthly.
Woodring, Jane Maryland.
Woodring, Judy asst. to managing editor. Scientific Monthly.

WOODS HOLE OCEANOGRAPHIC INSTITUTION

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BOTANY CLASS NOTES

(Continued from Page 8)

the afternoon and evening. Dr. Taylor demonstrated the extraction and separation of the pigments of blue-green algae, including phycocyanin. We determined the composition of cell walls by means of organic dyes.

Saturday saw the last of the blue-greens, and Monday we started on their more verdent brethren (chlorophyta, to you). The next day we went on a truck and tramp trip. Our prize specimen, *Coleochaete,* was found on a beer bottle, dredged from the depths of Coonamesset River. Up to our necks in the floating swamp, we salvaged many fine cryptogams, as well as two rubber balls and three tires for Uncle Sam. We returned with more specimens in boats than in bottles and proceeded to list some fifty-five genera. On Wednesday the morphology of the greens claimed our attention, as also did THE COLLECTING NET—with harrowing results—and so to press. —*J. B. and E. R.*

The National Research Council has given a grant of $3,000 to the Department of Physiology of the University of Virginia for work on endocrinology under the direction of Dr. Sydney W. Britton.

M.B.L. TENNIS CLUB

The Colas courts of the M.B.L. Tennis Club are ready for use and the beach courts are expected to be open soon. The "Mess" courts are within the Navy base enclosure and of course are not available this year.

The membership rates are the same as they were last year; $6.00 for a full membership, and $4.00 for persons wishing to use only the Colas courts. For M.B.L. students, there is a special rate of $3.00. For twenty-five cents an hour guests may play on the courts.

The officers of the Club this year are: *President,* Dr. E. G. Ball (who will be here only on week-ends); *Vice-President,* Mrs. Elsa K. Sichel; *Secretary-Treasurer,* Dr. T. C. Evans.

DR. MARGARET NAST LEWIS, the daughter of Dr. and Mrs. Warren Lewis, has received one of the Finney Howell Research Fellowships to work at the Crocker Radiation Laboratory at the University of California.

Circumstances brought about by the war situation will prevent the Woods Hole Choral Club from functioning this summer, after sixteen years of successful work. Professor Ivan T. Gorokhoff, Director of Choral Music at Smith College, formerly directed the Club.

THE COLLECTING NET

Vol. XVII, No. 2 SATURDAY, JULY 18, 1942 Annual Subscription, $1.00 Single Copies, 30 Cents.

ACTION OF ULTRAVIOLET ON CELLS

DR. ARTHUR C. GIESE

Associate Prof. of Biology, Stanford University

Some of the most important problems of life, for example photosynthesis, vision, mutation and vitamin D among others, are in a sense problems in photobiology — problems of the effect of light upon cells. It is not the purpose of this lecture to analyze the above major problems, since they involve enzymology, respiration, permeability, muscle-nerve physiology and other fields with which other lecturers will deal. Nor is it the purpose to list the various ways in which radiations have been used as tools in physiological research. Rather, an attempt will be made to develop the principles of light absorption by chromophores and its subsequent action by studying the way in which ultraviolet radiation acts on cells since many of the principles may then be applied to any problem involving the effect of light upon cells.

While the bactericidal action of sunlight was first noted by Downes and Blunt in 1877, considerable time elapsed before it (*Continued on page* 26)

M. B. L. Calendar

TUESDAY, July 21, 8:00 P. M.

Seminar: A. C. Giese and E. L. Tatum: "The Effect of Some Vitamins of the B Complex on Respiration of Neurospora."

K. C. Fisher and G. W. Scott: "Physiological Basis of Temperature 'Selection' by Fish."

J. R. Stern and K. C. Fisher: "The Action of Narcotics on the O_2 Consumption of Frog Muscle."

FRIDAY, July 24, 8:00 P. M.

Lecture: "Norway Fights On," Per Höst, Norway.

FRIDAY, July 31, 8:00 P. M.

Lecture: "On the Mechanism of Transmission of Nerve Impulses," Dr. David Nachmansohn.

NUCLEOLI AND PHYLOGENY

DR. R. RUGGLES GATES

University of London

The nucleolus, a nearly universal feature in plant and animal nuclei, has long remained a mysterious body whose composition, function and history in the nucleus was for the most part unknown. Discoveries made in the last decade have transformed this situation, so that nucleoli can now take their place with the chromosomes as structures of fundamental importance in interpreting nuclear history from species to species.

The nucleolus was first observed by Fontana in 1781 in the nuclei of epithelial cells of the eel. This central "spot" played a part in early conceptions of cell origin, the importance of which has not hitherto been fully recognized. In the 18th century, when Bonnet's emboîtement theory of embryonic development was in vogue, embryology could be thought of as a simple unfolding of preformed parts. Even the elements of chemistry and physiology were unknown, and of the conception of

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CLASS AND STAFF OF THE EMBRYOLOGY COURSE

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metabolism—a very fundamental idea in biology—there was naturally hardly a glimmer. Schwann and his contemporaries, Valentin, Bowman and others, about 1839, with the simple microscopes then available, were able to see in ordinary animal cells little more than the cell outline, the nuclear membrane and the enclosed nucleolus. Schwann's theory that the nucleolus expanded into a nucleus, which in turn became the cell, was thus a preformationist theory applied to the origin of the cell, just as Bonnet had applied preformationism to embryology nearly a century before. This view of cell origin, which was accepted in its essentials by Valentin, although he had already observed the real methods by which cells increase, can only be ascribed to the belated influence of 18th century preformationism and the absence of any knowledge to fill the gap now occupied by cell metabolism.

The nucleolus (plasmosome) remained a body whose functions in ordinary cells were obscure, although Montgomery in his well-known monograph in 1898 was able to show the part it played in the yolk production of animal eggs and in secretory cells. But these were special activities, and any general function of the nucleolus in the cell remained purely hypothetical. The part played by nucleoli in yolk formation has been abundantly confirmed by subsequent work with many animal eggs.

Definite information is now being acquired regarding the chemical composition of the nucleoli in animal and plant cells. Tests for lipoids made last summer[1] on the nucleoli of fresh eggs of Asterias, Arbacia, Mactra and Chaetopterus indi-

[1] Gates, 1942. Some observations regarding the nucleolus and cytoplasm in living marine eggs. Biol. Bull., 82: 47-51.

cated their absence, and the absence of phospholipids from the nucleolus, but incidentally the presence of acetalphosphatids in the cytoplasm. Caspersson and Schultz, using the ultra-violet absorption spectrum, found ribonucleic acid present in the nucleolus. There is reason to believe that this may be derived from the chromosome sheath. The absorption curve has its maximum at 2600Å and a hump near 2800Å. Ribonuclease and other protein enzymes, however, give similar absorption curves. The hump in the curve is believed to represent proteins containing tyrosine and tryptophane. Glutathione is also believed to be present, because the -SH radicle can be demonstrated. The nucleolus may also contain proenzymes, but chromatin is normally absent as well as lipoids. In the cells of plants which have been starved by being kept in darkness, the nucleoli decrease markedly in size. This together with a diurnal rhythm of nucleolar size (decreasing in size at night and enlarging by day) leads to the conclusion that in plant cells the nucleoli probably store sugars.

The fact that nucleoli generally stain like chromatin with Heidenhain long had a misleading effect on conceptions of the nucleolus. It was often supposed to be a storehouse of chromatin for the chromosomes. The Feulgen stain with Schiff's reagent showed the falsity of this view, since it colors the chromosomes red and leaves the plasmosome unstained. Fresh invertebrate eggs show the nucleolus in two parts, one enclosed within the other, the outer part being more soluble in fresh water than the inner. The central portion was formerly called oxyphil and the outer part basiphil by the histologists.

The need for a contrasting stain for chromatin and nucleoli led to the development of the Feulgen-light-green stain in my laboratory. After hydrolysis of the tissue and the usual stain with Schiff's reagent, the slide is mordanted with sodium carbonate and then given a short stain in light-green or Fast green. This stains only the nucleoli and the sheath of the chromosomes green, thus giving a sharp contrast which is essential for studying the origin of the nucleoli in telophase. The method requires only minor modifications from one genus of plants to another and has been successfully applied to animal cells. This has made possible the comparative study of nucleolar numbers and sizes in many plant genera.

Let us first follow the nucleolus through the mitotic cycle, beginning in telophase. In an ordinary diploid plant generally one pair of chromosomes has satellites. These bodies were discovered by Navashin in 1912. The satellite is a tiny ball of chromatin attached to one end of a chromosome by an extremely tenuous thread. We have shown that in some cases this thread is a spiral and stains with Feulgen. In Crocus root-tips it was possible to show that the chromosome consists of two strands close together, each with a terminal thread bearing a satellite. (These split satellites can sometimes be seen in anaphase, proving that the anaphase chromosome is already a double structure). With Feulgen-light-green stain the beginning of the nucleolus can be seen as a tiny green granule at the end of each chromosome strand, where the thread arises. The two granules are so close together that they shortly fuse into one, which grows into the full-sized nucleolus. Each nucleolus then arises from the tip of a chromosome body; this locus has been called by McClintock (1934) the nucleolar organizing body. It is not a visible structure but a locus at the end of a chromosome.

In early telophase the sheath of the chromosomes, which stains green, is sloughed off and an evanescent stage follows in which little green droplets are scattered throughout the nucleus. This material is used up and disappears in the growth of the true nucleoli. Movements of the chromosomes as they pass into the resting stage generally result in the nucleoli coming into contact. Having the consistency of a viscous fluid, the nucleoli fuse where they touch. By the resting stage they have generally all fused into one, whether there is one pair or several, but the chromosomes which produced them remain attached at the point of origin. In prophase they can be clearly seen with the contrasting stain—the red chromosome, with its thread and satellite, attached to the green nucleolus at the point from which it originated.

In determining the conditions as regards satellites and nucleoli in any new species, it is necessary to compare (a) the metaphase chromosomes and their satellites, with (b) the number of nucleoli in early telophase and (c) the number of chromosomes attached to the fused nucleoli in prophase. They must of course agree. The satellite is generally attached to the short arm of a chromosome, but sometimes, as in Crocus, they are attached to the long arm.

Instead of having a satellite, a chromosome may be constricted nearer the middle and produce its satellite there. This appears to be just a matter of where the locus of the nucleolar organizer is fixed. The primary constriction is for the spindle

"The Collecting Net" was entered as second-class matter July 11, 1935, at the Post Office at Woods Hole, Mass., under the Act of March 3, 1879, and was re-entered on July 23, 1938. It is devoted to the scientific work at marine biological laboratories. It is published bi-weekly between July 1 and September 1 from Woods Hole, and is printed at The Darwin Press, New Bedford, Mass. Its editorial offices are situated in Woods Hole, Mass. Single copies, 30c; subscription, $1.00.

fibre attachment, so the constrictions which produce a nucleolus are called secondary. There are also fixed secondary constrictions in certain chromosomes, which do not produce a nucleolus but are a constant morphological feature of the chromosome. Thus there are many points in chromosome and nucleolar morphology besides numbers, which can be used in comparing plant species. In animals, *Amblystoma* is one of the few species in which these relationships have been followed, and there the situation is exactly as in plants.

In pollen mother cells, where the structures are larger, Latter (1926) found what she called the nucleolar body, a darker staining portion of the nucleolus at the point of attachment of what we know now is the satellite pair of chromosomes. It has since been observed in various other plants and has also been figured in the corresponding stage of animal spermatogenesis. We have since shown that this nucleolar body is not chromatin. It is a portion of the nucleolus at the point where the nucleolus arises from the chromosome under the control of the organizer.[2] In the much smaller somatic cells it has only been seen in rice (Nandi, 1937) as a knob at the point of attachment.

In plant cells the simplest condition is one in which a diploid species has one pair of nucleoli, a tetraploid two pairs, a hexaploid six nucleoli. This is the condition, for instance, in wheat; and in *Triticum spelta* ($2n = 42$) the three pairs of nucleoli differ markedly and constantly in size. In animals, Conklin pointed out in 1902 that the cleavage nuclei of Crepidula have two nucleoli. But Mead in 1898 and F. R. Lillie in 1912 found that in Annelids each chromosome in telophase generally forms a vesicle containing one or two nucleoli; so the possible phylogenetic value of nucleolar numbers in animal cells remains to be explored. It should prove to be a field of great interest.

We may now examine a few of the results regarding nucleolar numbers and their significance, which have been obtained in my laboratory during the last five years. There are hundreds of varieties of cultivated rice (*Oryza sativa*) in the Orient. They all have 12 pairs of chromosomes, and most varieties have two pairs of nucleoli which are produced by two pairs of chromosomes with satellites so minute that they are frequently not seen. It appears that in many genera of plants only one pair of nucleoli is necessary for the life of the cell. Doubling of the chromosomes in a tetraploid form will result in four nucleoli. There is much evidence that cultivated rice, with its 12 pairs of chromosomes, is an allotetraploid derived by crossing between two original species with 5 pairs of chromosomes. This sterile hybrid doubled its chromosomes and duplicated two pairs, thus producing 24 chromosomes, four of which produce nucleoli. This ancestral history is shown partly by the secondary pairing of bivalents in the pollen mother cells, which is a test of homology. The maximum pairing, which has been observed in two different species of Oryza, is two groups of three and three groups of two, indicating that five is the basic number. This is confirmed by finding that in species of two genera related to Oryza the chromosome numbers are respectively 30 and 40. In these genera the chromosomes are therefore in high multiples of five, while the genus Oryza began its existence by changing to a basic number of 12, as indicated. Other nuclear changes have occurred since. In certain varieties of cultivated rice there has been a mutational loss of one pair of nucleolar organizers, the chromosome numbers remaining the same. These varieties produce only two nucleoli. In certain other species of Oryza, in India and Africa, the chromosomes have been doubled, probably again after crossing between species, giving 48 chromosomes and eight nucleoli. These species are therefore secondary octoploids.

In several other plant genera, even with low chromosome numbers, the condition with two pairs of nucleoli has become stabilized. These two pairs may differ in their composition, and both appear to be necessary for the life of the cell. In Oenothera, with $2n = 14$ chromosomes, primitive homozygous species such as *O. Hookeri* have two pairs of nucleoli of unequal size. Similar conditions exist in all the species examined, except one which has constantly five nucleoli. How the extra nucleolus arose is at present unknown. In the nearly related genus Gaura the conditions are very similar, with catenation of the chromosomes in diakinesis and two pairs of nucleoli of unequal size. These two pairs of nucleoli probably differ in their composition and may conceivably correspond with the oxyphilic and basiphilic portions of the nucleoli in animal eggs.

In wheat the nucleoli are equally useful in tracing the phylogeny of species. *Triticum monococcum* is another diploid species ($2n = 14$) with four nucleoli arising from four satellite chromosomes. *T. durum* ($2n = 28$) also has four nucleoli, but two arise from sat. chromosomes and two from secondary constrictions on another pair. In the hexaploid *T. vulgare* ($2n = 42$) there are six nucleoli. Similar conditions hold in the nearly related genus Aegilops, which has probably taken part in the ancestry of our cultivated hexaploid wheat. Rye, with $2n = 14$, has two nucleoli produced not from satellites but from secondary constrictions. Without entering into details of the origin of bread wheat, it will be seen that the morphology of the nucleolar chromosomes is of great

[2] The whole subject of the nucleolus has recently been reviewed: Gates, 1942. Nucleoli and related nuclear structures. Bot. Rev., 8: 337-409.

value in tracing the origin of its six sets of chromosomes, which have come together from different sources, partly through crossing.

In the genus Crocus the basic number of chromosomes is only three. Various species have different multiples of this and other derived numbers. The number of nucleoli may be 2, 4 or 6 and the pairs generally differ constantly in size. *Crocus sativus*, however, which has 24 chromosomes and should therefore be an octoploid, has only three satellites and three nucleoli. The other five nucleolar organizers have been lost. In this genus the satellite is frequently on the long arm of the chromosome, so it projects like a finger from the nucleus in telophase. In this genus there appears to be a definite relation between the size of the satellite and the size of the nucleolus. This raises the question, which we cannot answer at present, whether the satellite plays some definite part in the production of the nucleolus. The connecting thread seems to be stretched and despiralized as the nucleolus grows, but there is no obvious reason why a larger satellite should be accompanied by a larger nucleolus, especially as the locus (organizer) at the tip of the chromosome is mainly, if not entirely concerned in producing the nucleolus.

Another question which requires an answer is why the nucleoli grow from these particular loci and not from others. They seem to act as a sump at which the scattered material from the chromosome sheath aggregates. This could be explained by assuming that the organizer bears a stronger electric charge than other parts of the chromosome, but this in turn would require an explanation. There is considerable evidence that the growing nucleoli and the chromosomes repel each other. Since the chromosomes bear a negative charge, an intense positive charge at the organizer could be assumed, but there is no known way in which such a difference of potential could be maintained while these bodies are in contact.

The large genus Allium is another in which 2n, 4n and 6n species generally have the corresponding numbers of nucleoli. The basic number of chromosomes here is probably 8, from which species with 7 or 9 as fundamental number have been derived. Two Californian species are interesting exceptions. *A. amplectens*, a diploid endemic species ($2n = 14$) is not only asynaptic but has lost its nucleolar organizers, so that an indefinite number of free "nucleoli" are found in the cells. *A. Bidwelliae*, a tetraploid with 28 chromosomes, which is described as having ten nucleoli, all produced from secondary constrictions, is possibly in the same condition. Such loss of organizers appears to occur mainly in species in which the chief method of reproduction is vegetative. In Trillium, which has the largest chromosomes and the smallest satellites of any flowering plant, and in which the species grow mainly from root-stalks, the satellites are so minute that they can generally be seen only with great difficulty. They are in effect vestigial organs, at the vanishing point. In some species they have disappeared entirely along with the organizer, and the nucleolar material remains scattered throughout the nucleus. Thus the loss of the satellite may be a slow and gradual process, as in Trillium, or it may be a sudden mutational loss, as in rice and various other species.

In the genus Narcissus, the satellite pairs of chromosomes are frequently heteromorphic, indicating that a satellite has undergone translocation from one chromosome to a member of a different pair. Sometimes reversal of a portion of a satellite chromosome produces a chromosome in which the satellite and its thread are laterally attached. In Narcissus the time element is conspicuous in relation to nucleolar production. Generally one pair of nucleoli begins to appear in anaphase. These continue to grow and form the largest pair of nucleoli. In a triploid variety in cultivation two nucleoli appear in anaphase but grow at unequal rates. The third can first be seen in telophase and remains very small. Thus there is clearly competition between the organizers for the available material for nucleolar growth. In certain hybrids of Crepis species, in the condition which M. Navashin called amphiplasty, a satellite may be suppressed, probably because the nucleolar organizer at that locus fails to obtain nucleolar material in competition with the others. That it has not been lost is shown by its reappearance when this hybrid is crossed back with the parent form.

The great family of Leguminosae shows many interesting features as regards chromosome numbers and nucleoli. There is much evidence that 4 was the basic chromosome number in this family and this is confirmed by the nucleoli. For instance, *Clitoria ternata*, with $2n = 16$ chromosomes, has four nucleoli arising from four satellite chromosomes. Similarly, *Cicer arietinum* with 16 chromosomes and *C. soongaricum* with 14, each have four satellites. *Poinciana regia* with 28 chromosomes has seven nucleoli, confirming that it is a heptaploid species. The genus Cassia apparently represents a derived condition, with change to seven as basic chromosome number. *C. auriculata* has $2n = 14$, with only two nucleoli. In *C. siamea* ($2n = 28$) there are four nucleoli and in several other tetraploid species only two nucleoli are present, indicating that a pair has been lost since the chromosome doubling took place. This and much other evidence indicates that a new genus of plants has frequently been inaugurated by a rearrangement of much of the nuclear material into a new pattern.

In the genus Calceolaria (Scrophulariaceae) nucleolar numbers have been similarly used in interpreting the meaning of chromosome numbers. In *C. Pavonii* ($2n = 36$) eight chromosomes are attached to the nucleolus in prophase. As nine is the basic chromosome number in this genus, it is not clear how this condition has arisen.

Brassica is a genus of the Cruciferae in which many chromosome numbers occur and we have shown that many of the species are amphidiploids, *i.e.* species hybrids which have doubled their chromosomes, and so produced a new, fertile and stable species. The conclusions based on chromosome numbers are confirmed by the numbers of satellites and nucleoli involved. For instance, *B. juncea* has 36 chromosomes, six of them with satellites, producing six nucleoli. *B. campestris* ($2n = 20$) has one pair of satellites which produce nucleoli. When these species are crossed, the hybrid shows in pollen formation ten bivalent chromosomes and eight unpaired. This indicates that 10 of the chromosomes of *B. juncea* are homologous with those of *B. campestris*. *B. nigra* is a species with $2n = 16$ chromosomes, four of them with satellites and producing nucleoli. From this and other evidence it is clear that *B. juncea* arose as a new species from a cross between *B. nigra* and *B. campestris*. This sterile hybrid would have 18 chromosomes and three nucleoli. Doubling of the chromosome set produced *B. juncea* as we find it, with 36 chromosomes and six nucleoli.

We may conclude from these and many other recent discoveries regarding the nucleolus, that after a long period of obscurity it has now entered upon a new era of activity. The nucleolus is now prepared to take its part, not only in considerations of species phylogeny but also in studies of cell physiology. We know the history of its origin in the mitotic cycle and its final disappearance in the cytoplasm, probably carrying with it substances that are vital for the growth of the cell. The fact that these substances carry materials from the chromosome sheath which have been closely in contact with the genic core of the chromosomes and that they are finally dumped in the cytoplasm may not be without significance. It is to be hoped that animal cytologists in particular will devote more attention to the nucleoli in their studies, and if the conditions are anything like those in plants a rich harvest awaits them.

(This article is based upon a lecture delivered at the Marine Biological Laboratory on July 10.)

ACTION OF ULTRAVIOLET ON CELLS

(Continued from page 21)

was demonstrated that it was the ultraviolet rays of sunlight which were bactericidal and that they acted directly upon the bacteria (see Duggar, 1936 ch. 36). Then towards the close of the century Finsen in Denmark applied ultraviolet radiations to ulcers of lupus vulgaris and his success stimulated considerable work with radiations much of which was done in his Lichtinstitut. It soon became evident that the ultraviolet could be divided into two main regions, a non-lethal or biotic region from 4000-3000 Å and a lethal or abiotic region from 3000 Å to the short wavelength limit of the ultraviolet. We shall here consider mainly the abiotic region because it is the most active photochemically and has been shown to be not only bactericidal but also lethal to molds, yeast, plant cells, protozoans, and small metazoans and to cause sunburn in man. While reports have been made claiming considerable destructive action in the biotic region (Weinstein, 1930), careful studies using delicate indicators of ultraviolet action show that even relatively large dosages of biotic ultraviolet have but little effect compared to the abiotic (Giese, 1938b). It has been found, however, that insects see the biotic ultraviolet and it may be that upon further study other organisms may be found to respond to or in some other way utilize this part of the ultraviolet spectrum (Duggar, 1936 ch. 17).

That so sharp a dividing line between the abiotic and biotic ultraviolet should appear is not surprising if we consider that organisms adapt themselves to their environment. For while the sun, as a black body with a surface temperature of approximately 6000° C., gives off a considerable amount of short wave ultraviolet, the short rays are absorbed by oxygen about 20 miles up in the atmosphere resulting in the formation of ozone (Stetson, 1942). This ozone in turn absorbs more of the ultraviolet and in so doing becomes decomposed into oxygen. The sunlight transmitted through these screens has a short wavelength limit of about 2860 Å and no shorter wavelengths are observed even on plates exposed in balloons under optimal atmospheric conditions. Under usual environmental conditions, therefore, organisms are only briefly, if at all, exposed to radiations shorter than 3000 Å. Consequently life has evolved in such a way that these wave-lengths present in sunlight in relatively high intensity have no harmful effects on organisms except in huge dosages.

Since cells are affected by the short ultraviolet it is evident that they must possess substances which absorb these radiations, for, according to the Grotthus-Draper Law, only light absorbed is effective in promoting a photochemical reaction. It is well known that in the visible portion of the

spectrum various atomic configurations such as the quinoid ring, the azo, axin and indamin groupings act as *chromophores* enabling the molecule to absorb light as a result of which the absorbing molecule is colored. It is important to find similar chromophores absorbing ultraviolet light in order to further analyze the action of these radiations upon cells. This can be done in three ways (1) by determining the absorption of ultraviolet by the various types of chemical compounds found in the cell; (2) by determining their absorption by suspensions or layers of cells and (3) by irradiation and observation of the comparative effect of different wave-lengths on cells and from this their *action spectrum*. There is at present available a fairly consistent body of data as to the probable chromophores.

Studies on the absorption of ultraviolet by types of compounds present in protoplasm indicate that inorganic salts, carbohydrates and fatty materials absorb only rather generally in the ultraviolet, the absorption increasing with decrease in wavelength and varying with concentration and other factors. But the proteins and nucleoproteins show highly specific absorption each with a characteristic curve (Caspersson, 1936). For serum albumin, which might be taken as an example of cytoplasmic protein, the absorption spectrum shows one maximum at about 2800 Å, another below 2400 Å and a minimum at about 2550 Å; on the other hand thymonucleic acid, which might be taken as an example of nucleoprotein absorption, shows a maximum at about 2600 and another at wave-lengths shorter than 2200, with a minimum at about 2300 Å. In both cases the absorption falls off rapidly toward 3000 Å. Furthermore nucleoproteins are more opaque to ultraviolet than the cytoplasmic proteins for thymonucleic acid in 0.1% solution absorbs comparably at its 2600 Å maximum to a 10% solution of serum albumin at its 2800 Å maximum. In albumin and similar proteins it is the aromatic amino acids such as tyrosine and tryptophane which bear the main chromophores; in the nucleoproteins, it is the purines and pyrimidines of the nucleic acids which bear the main chromophores (Caspersson, 1936).

Measurement of absorption of ultraviolet radiations by cells and organisms is difficult owing to the scattering of these rays from the surface of cells and from the granules within the cells, and the uncertainty of corrections for this scattering. Gates (1930) using thin layers of bacteria with a small scattering error records a maximum at 2500-2600 Å and after a small minimum a second maximum in the short wave end which he measured. Studies on paramecia and sea urchin eggs (Giese and Leighton, 1935; Giese, 1938a) with a large scattering error indicate maxima at 2804 and 2537 Å for the wave-lengths tested. Absorption measurements have also been made for a few wave-lengths by photographing Euglena with ultraviolet light using a microscope with quartz lenses (Swann and del Rosario, 1932). Similar experiments with single eggs involve optical difficulties (Vles and Gex, 1934) but suggest a small maximum at 2800 Å. Human epidermis also shows a maximum at 2700-2800 Å and a minimum at 2500-2600 Å (Blum, 1941, ch. 17). Thus the absorption by bacteria, while not corresponding to the nucleoprotein curve, suggests it, while the absorption by the larger cells suggests the cytoplasmic absorption curve, but further studies especially with the photographic method are desirable to decide the matter. While the above generalization may hold for suspension of cells, photographs indicate that the nucleus absorbs far more completely than the cytoplasm. In the nucleus the chromosomes show the characteristic absorption spectrum of the nucleoproteins while the cytoplasm may show an absorption similar to serum albumin (Caspersson, 1936).

The action spectrum of ultraviolet light on cells as determined by studying (1) the bactericidal effect, (2) the lethal or retarding action on yeasts, molds, tissue culture (Duggar, 1936, ch. 36), and the mutation rate (Stadler and Uber, 1942) shows maxima and minima such as one might expect if the nucleoproteins were the most important absorbing agents. However, data on the lethal effect on paramecia (Giese and Leighton, 1935) and pinworm eggs (Hollaender, Jones and Jacobs, 1940) and of retardation of division in paramecia and marine eggs (Giese, 1938a; 1939c) show maxima and minima suggestive of a major effect on cytoplasmic proteins. On the other hand this conclusion may be more apparent than real for when the recovery of paramecia from the effects of the radiations was studied it was found that recovery from 2804 was much more rapid than from 2654 Å. Perhaps even more convincing are experiments in which the retardation of cleavage following irradiation, with 2654 Å, of eggs on the one hand and of sperm on the other, are compared on the basis of the number of quanta removed. The sperm were found to be affected by one millionth the number required by the eggs. Unless the sperm are more sensitive in general, this means that the nuclear constituents are extremely vulnerable compared to the cytoplasmic (Giese, 1939b). There are, however, definite evidences of purely cytoplasmic effects as well. Thus activation of eggs of Arbacia begins at around 2654 Å and the effectiveness of radiations increases with decrease in wave-length to the shortest tried (Hollaender, 1938). Also the studies of Schleip (1923) in which only the cytoplasm of an Ascaris egg was irradiated with a small beam of 2800 Å and abnormal development

occurred. Apparently both cytoplasmic and nucleoproteins may act as chromophores perhaps the former accounting for the greater part of the effect under most conditions, the latter under other conditions. However most of the action spectrum studies have been done with only a few wave-lengths; to clinch the matter, these studies should be extended to the short wave end of the quartz ultraviolet where differences in nuclear and cytoplasmic protein absorption are most distinct. It should be pointed out that not all nucleoproteins are confined to the nucleus (Caspersson and Schultz, 1940) therefore correlation with nucleoproteins does not necessarily imply effects on the nucleus or in the nucleus alone.

Following the absorption of ultraviolet light by the chromophores in the cells energy rich molecules are produced and according to the Einstein-Stark law of photochemical equivalence for every quantum absorbed one light-absorbing molecule should react. This process is often called the *primary reaction* and is not influenced by temperature or by other tested variables acting at the time of irradiation (Gates, 1929). The amount of energy which must be absorbed to produce an effect upon cells is exceedingly large; thus, while the division rate of cells is a fairly delicate indicator of injurious effects, sea urchin eggs and paramecia were able to receive 10^9 quanta of short wave ultraviolet without being retarded in cleavage although 10^{11} quanta produced retardation (Giese, 1938a; 1939a). Apparently a large number of light activated molecules must be produced before injurious effects are obtained. Within certain limits tested it does not seem to matter whether the required dosage is applied at high intensity for a short time or at a low intensity for a longer time, in other words, the Bunsen-Roscoe reciprocity law seems to hold. Thus a flash of high intensity for about a millionth of a second was as effective as an exposure of several seconds or minutes both for bactericidal effects (Rentschler, Nagy and Mouromseff, 1941) and for retarding division in paramecia (Rentschler and Giese, 1941).

Energy rich molecules produced by absorption of light must void this energy in one of a number of ways, these reactions being called *secondary reactions*. In chemical systems the energy may (1) be emitted as fluorescence, (2) be transferred to other molecules (photosensitization), (3) result in the polymerization or photolysis of the energy rich molecules, or (4) lead to the reaction of these molecules with others bringing about oxidations, substitutions or a shift in equilibrium of a process already occurring (Duggar, 1936). In protoplasm the energy may possibly be voided in the same ways. Fluorescence is a well known phenomenon as the result of ultraviolet light (Giese and Leighton, 1933) and indicates that the absorbing molecules have a long life of activation, but precisely what other reactions occur in the cell is not known although various changes in cell structure and activity can be observed and serve as an index of the secondary reactions. Some of these observable changes in the structure of the cell are (1) a change in viscosity, first a decrease and then with larger dosages an increase (Duggar, 1936, ch. 18). The determination of the action spectrum of these changes in viscosity would be valuable for correlation with other data. (2) Change in dark field appearance suggestive of coagulation (Tschakhotine, 1921), (3) numerous nuclear abnormalities such as the thickening of the nuclear membrane, unequal division and unequal distribution of chromosomes in division, abnormal chromatin elimination, extra spindles leading to abnormal cleavage (Schleip, 1923), (4) production of abnormalities in cells with a tendency to abnormality in at least asexual reproduction as shown in cultures of ciliates and induced tumors (Mottram, 1942). Since this problem is closely related to cancer research additional studies would be of great value. (5) Genetic changes heredity in sexual reproduction (Stadler and Uber, 1942).

Some of the observable changes in activity are: (1) increases in movement subsequent to slight dosages; (2) decrease in such activity as shown by a slowing down of contractile vacuolar and ciliary movement in protozoa or streaming in plant cells; (3) retardation or complete inhibition of cell division, probably indicative of a disruption of normal synthetic reactions (Giese, 1941); (4) changes in permeability (Duggar, 1936 ch. 18). While changes in permeability have been claimed in the past, recent studies with sea urchin eggs indicate no appreciable change in permeability to water and organic molecules after tests with a wide range in wave-length and dosage (Reed, 1942). None of the studies yet performed have been made with the short quartz ultraviolet so effective in parthenogenesis nor with the superficially absorbed Schumann rays (Bovie and Daland, 1923). (5) changes in oxygen consumption (Duggar, 1936, ch. 32). Recent studies have shown that just lethal dosages may have no immediate effect on total oxygen consumption although huge dosages cause a decrease (Anderson and Duggar, 1941; Giese, 1941). Under certain nutritional conditions an increase may be obtained even after a lethal dosage (Giese, 1942). Atmospheric oxygen is however not necessary for the action of ultraviolet rays on cells as was shown long ago in Finsen's laboratory.

The mass of data listed above suggest that many secondary reactions of various types follow the irradiation of cells. It is also known that these

secondary reactions are influenced readily by temperature (Bovie and Daland, 1923; Anderson and Duggar, 1941). There is also some evidence that these reactions may be quite indirect. Thus Hertel (1905) found that if one cell of a cleaving egg were irradiated with a lethal dose just before the furrow formed, the second cell cytolyzed, whereas if this were done after the cells separated, the second blastomere was not affected. Also Schleip (1923) irradiating the cytoplasm of Ascaris with a point of light found that subsequently nuclear abnormalities appeared. However, normal cells placed in medium containing photolysed cells were not affected. Whatever the nature of the intermediate secondary reactions, we know that the light is absorbed by chromophores in proteins and that ultimately denaturation of the proteins occurs. Examination of some of the findings from studies on denaturation of proteins may thus help interpret the biological findings.

Protein denaturation by ultraviolet light occurs in three steps: (1) light alteration of the molecules; (2) chemical change developing the light effect and rendering the molecule insoluble and (3) aggregation of the molecules to form a flocculum (Clark, 1935). Step (1) can be shown to occur separately from (2) by irradiating the solutions at low temperatures at which (1) being a photochemical reaction will occur but (2) being a thermochemical reaction, cannot occur. Raising the temperature will now result in (2) followed rapidly by (3). Step (2) can be shown to be separate from step (3) by irradiating pure protein to one side of the isoelectric point in the absence of salts. Then (1) will depend upon the dosage, (2) will vary in rate depending on the temperature, (3) will occur only on properly changing the pH.

Denaturation is in some cases a reversible reaction in which the proportions of native and denatured protein depend upon the conditions affecting the equilibrium between the two. As such the linkages involved are thought to be secondary bonds (Anson and Mirsky, 1934). While such reactions may occur after small dosages of ultraviolet there is evidence that more than this may occur after greater dosages for Carpenter (1941) has recently shown that the C-N bond in dipeptides can be broken by ultraviolet rays. His experiments indicate that the chromophore can transfer the absorbed energy across the two carbons in sufficient quantity to break the C-N bond. The appearance of proteoses and peptones and even free amino acids in irradiated protein solutions indicate that the same may happen in proteins, in other words, that the peptide linkage is broken. Even more drastic breakages may occur, for the characteristic protein band at 2800 Å disappears after prolonged irradiation indicating that the chromophoric rings are altered or destroyed. Appearance of ammonia is further evidence of photolysis (Arnow, 1936).

There is ample energy in quanta of ultraviolet light to break such bonds. Thus the gram molecular quantum value $Nh\nu$ is 71,200 calories per mole at 4000 Å and 142,000 for 2000 Å. The energy required to break a C-C bond is 58,600 calories per mole, a C-N bond, 48,600 and a C=C bond, 100,000 (Pauling, 1939). The utilization of photochemical energy involves a transfer from the chromophore to the bond broken; losses in such a transfer may account for apparent inefficiency, but transfer occurs as pointed out above (Carpenter, 1940 and 1941). However drastic changes are not necessary to affect the catalytic properties of protein molecules (Anson and Mirsky, 1934; Chase and Giese, 1940).

We may conclude that in cells a wide variety of effects occur following irradiation, depending on the wave-length and dosage. Effects such as the loss of the ability to divide caused by relatively small dosages may merely involve small changes in the specific properties of catalytic molecules. Effects such as the decrease in respiration following larger dosages probably involve larger changes. Complete disruption of cell activities ending in cytolysis probably involves more violent action ending in photolysis of proteins and other molecules in the cells. It is evident that our knowledge of the secondary reactions is still incomplete and additional work is necessary before a more specific analysis is possible.

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(Continued on page 34)

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Judy Woodring and Jane Woodring.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

Introducing

Mr. Per Höst, who will give the Friday evening lecture, "Norway Fights On," on July 24, at eight o'clock, is a young zoologist formerly associated with the University of Oslo in Norway. He has been a specialist in surveying the distribution and habits of the birds and mammals of northern Norway and of the Arctic. There he made careful and prolonged observations by means of photographic recording to show the occurrence and habits of animals in their natural background.

Mr. Höst has also carried on surveys of animal distribution in field work for the New York State Authorities. More recently he has been associated with the American Museum of Natural History, as naturalist and photographer with the Archbold Expeditions. In that field work he has recorded studies of the interesting and abundant bird life of the swamps and sand scrub regions of Florida.

Like so many Norwegians in this country, Mr. Höst has joined the Royal Norwegian Air Forces at Toronto where he has secured photographic records of training operations. He has also assembled and edited the extensive film records which were available to show action during the invasion of Norway and the brave resistance of the Norwegians during the cruel German attack.

Norway saved most of its large and efficient merchant marine and some of its surviving naval vessels to continue the fight from outside. The Norwegians have also organized aviation and land forces with particular reference for their ability to work in the North. These men have a strong determination to restore the freedom of their country and people, and their character, physique and organization show that they will have a strong effect when the right time comes.

Mr. Höst was prepared for biological work at the University of Oslo and in the expeditions for scientific exploration in the North, which are so strongly supported by public and private interests in Norway. That background has made him a keen observer of the struggle among animals for existence and it now makes him an expert recorder of events in the great struggle for human freedom. —*Laurence Irving*

ADDITIONAL INVESTIGATORS

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CURRENTS IN THE HOLE

At the following hours (Eastern War Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
July 18	7:55	8:15
July 19	8:40	9:06
July 20	9:30	9:59
July 21	10:21	10:57
July 22	11:16	
July 23	11:56	12:14
July 24	12:56	1:12
July 25	1:54	2:09
July 26	2:50	3:05
July 27	3:45	3:59
July 28	4:36	4:53
July 29	5:27	5:44
July 30	5:46	6:35
July 31	7:05	7:27
August 1	7:55	8:19
August 2	8:44	9:13
August 3	9:36	10:08

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The course in Invertebrate Zoology at the Marine Biological Laboratory begins on July 24. Dr. A. J. Watterman, associate professor of biology at Williams College, is in charge. This year there will be about half the usual number of students in the course.

Two of the courses at the Marine Biological Laboratory terminate next week. The class in Embryology completes its work on Tuesday, and the one in Physiology two days later. The class work in Botany runs through August 1.

DR. H. B. STEINBACH, who has been assistant professor of zoology at Columbia University, will join Dr. Viktor Hamburger in the Department of Zoology at Washington University in Saint Louis as associate professor of zoology in September.

CHARLES B. METZ, who is teaching embryology this summer at the Marine Biological Laboratory, has been appointed instructor in biology at Wesleyan University. He recently completed his work for a doctorate at the California Institute of Technology on the problems of fertilization.

DR. VANCE TARTER, who had been instructor in zoology at the University of Vermont, has been appointed instructor in zoology at Yale University, from which he received his doctorate a year ago. Dr. Tarter was to have taught in the invertebrate course in zoology at the Marine Biological Laboratory in August, but his new appointment makes this impossible.

DR. J. H. MCGREGOR has been retired from the faculty of Columbia University, where he has been professor of zoology since 1924. He taught zoology at the Marine Biological Laboratory from 1899 to 1906.

DR. JOHN PRICE, of the Department of Zoology and Entomology, has been promoted from associate professor to a full professorship at Ohio State University.

DR. THEODOSIUS DOBZHANSKY, professor of zoology at Columbia University, is spending the summer in the mountainous parts of California and Nebraska collecting wild species of Drosophila for his evolution studies.

DR. LORANDE L. WOODRUFF, professor of protozoology at Yale University, is stationed at Yale University this summer, but he spends almost every week-end at Woods Hole at his cottage in the Gansett Woods. At the end of December he was appointed president of the American Society of Zoologists.

DR. VIKTOR HAMBURGER, professor of zoology at the University of Washington, is the author of the "Manual of Experimental Embryology" which is to be published shortly.

MRS. LILLIAN MORGAN SCHERP has been visiting her parents, Dr. and Mrs. T. H. Morgan, for a couple of weeks. She has just returned to her position as medical social worker for Strong Memorial Hospital, which is affiliated with the University of Rochester Medical School, where her husband, an immuno-chemist, is an assistant professor.

LORANDE M WOODRUFF, M.D., the son of Professor Woodruff at Yale, is now connected with the Chelsea Naval Base in Boston and conducting medical research at the Peter Bent Brigham Hospital. He was married on June 6 to Ann Fay, daughter of Mr. and Mrs. Henry H. Fay of Concord and Woods Hole.

ARTHUR WOODWARD, who for the past year has been research assistant to Dr. Edward C. Schneider at Wesleyan University, was married about two weeks ago to Mary Chamberlin, who was here here last summer.

DR. T. F. ANDERSON is demonstrating the electron microscope to those interested each Saturday morning from 9:00 to 11:30 in Room 311 of the brick building.

The group of people "singing songs from many lands" will assemble for the third time at 8:00 on Wednesday evening in the M.B.L. Club. The leaders cordially invite anyone interested to attend the songfest.

TRUSTEE VACANCIES AT THE M.B.L.

Dr. P. B. Armstrong, Clerk of the Corporation of the Marine Biological Laboratory, has recently had mailed to Corporation members the usual nomination blank with information about the trustees to be elected at the annual meeting next month.

The trustees whose terms expire are Drs. Brown, Clark, Glaser, Harvey, Jacobs, Knowlton, Schrader and Willier. All of these men are eligible for re-election. There are two further vacancies brought about because Drs. Mast and Mathews have past the age of seventy years and are no longer eligible to serve actively. Members of the Corporation should thus nominate ten persons from among their group for the guidance of the nominating committee, the members of which are not made known this year.

EMBRYOLOGY CLASS NOTES

Within the past two weeks, Dr. Hamburger's budding embryologists have had a taste of experimental embryology as well as tastes of clam and lobster. After dinner activities consisted of discussions on gradients, genes, and steam for the picnic sea food.

The second evening seminar in the embryology lab was opened by Dr. Rulon's concluding words on axial gradients. For at least one night communism and the second front in Europe vanished from the bull sessions as the pros and cons of gradient theories flew back and forth in the wee small hours.

With attention divided between fertilizins (Metz '42) and praying for a sunny Fourth, we put the finishing touches on the laboratory phase of the class echinoderm experiments.

"Clams: their feeding habits and mechanisms or how to clean a bivalve" was the first subject considered Friday evening. A special angle of a closely related topic was discussed by a small group in the back room of the Mess Hall. The topic was well covered with butter and jam as 210 sandwiches passed under the knife. By the time this cracker-barrel club dispersed, Woods Hole was under military order with uniforms and bayonets enforcing one way traffic around the Eel Pond.

After almost forgetting the precious barrel of sea food, embryologists and physiologists steamed under the Eel Pond bridge headed for the sandy beach of Tarpaulin Cove to celebrate Independence Day. Landed, by skiff or dogpaddle, the embryos versus the physiologists indulged in some fast sand-lot baseball. Due to hunger and aching muscles, the game was called at the end of the fifth inning with the embryos in the lead (9-7). A clothesbasket of sandwiches, two wash tubs of drink, a carton of ice cream, and a barrel of *Mya, Mytilus*, and *Homarus* (with appreciation to the N.Y., N.H. & H.R.R. for the steaming) offered entertainment to everyone for the next few hours but especially to the uneducated Mid-westerners. Before backs turned from pink to red, we were again aboard our vessels cutting our way through the fog to the tune of the tooting fog horn.

By Monday morning we had cooled sufficiently to tackle group experimental problems. *Tubularia* were drawn and quartered and tied in the middle by the group studying regeneration with Dr. Barth. *Molgula* and *Botrylus* joined the wartime acceleration movement for the students investigating metamorphosis under Dr. Grave. A group working with Dr. Watterson tried to separate the blastomeres of *Hydractinia* with needles the size of crowbars. Dr. Rulon had charge of problems on axial gradients, while Dr. Spiegelman's student discovered that eggs breathe faster in the presence of sperm than when alone. Fish hybrids, cyclops, and *Fundulus* embryonic transplants were made under the leadership of Dr. Hamburger. The experimental period was climaxed on Friday by an all day session of reports and discussions after an all night session of preparation by some of the victims. 4 P. M. brought satisfied expressions to the faces of profs and students as Dr. Hamburger proclaimed us all cooperative guinea pigs.

Accompanying the the experimental period was a series of three lectures on genes and development. Dr. Watterson, speaking on fowl pigment, opened the series with another of his well-packed lectures. Wednesday morning ex-instructor-in-charge Goodrich told us how fish got their colors. In the final lecture of the gene-development series, Dr. Hamburger related his studies of the dominant lethal Creeper factor in chicks. The second guest speaker of the week, Dr. A. W. Pollister, gave us the inside story of the cell, beautifully illustrated with many photographs of mitochondria and Golgi.

Among non-academic activities of the week, Edie Cole's house-warming proved spirit-warming and inspired some adventurous souls to a midnight jaunt on Penzance. The week-end brought still further departures from the scholastic realm. The most daring escapade was the voyage of a nameless sailboat under the skipperage of "The Ancient Marooner" with his crew of six. Destination was undetermined, their ports numerous, and by Sunday night it was obvious that their return would be later than expected. Monday they put to shore at regular intervals to telephone their progress from Vineyard to Falmouth and back again, and it was evening before the scarlet navigators tied up at the Eel Pond dock. Half of the class watched their triumphal entrance under the Main Street bridge and longed for a band to play "Three times around went our gallant ship."

—*E. C. and J. S.*

M.B.L. CLUB NOTES

The business meeting of the M.B.L. Club originally scheduled for Monday, July 20, has been postponed until August 3, at 7:00 P. M. The order of business will be: reading of the minutes of the last meeting, reports of officers, reports of committees, election of officers for next year and general business.

Miss Nora Clark is acting-chairman of the social committee of the M.B.L. Club in the absence of Mrs. Hobson.

BOTANY CLASS NOTES

Last week you heard about our course, and now we'd like to tell you something about ourselves. Picture us on the *Nereis* on one of our recent field trips to Pasque. Standing watch is Harold Arrowsmith, our navigator from Johns Hopkins, dressed as usual in khaki and knee boots. While Harold keeps an eye out for submarines, less fortunate sailors are provided for by the enthusiastic knitting needles of Jane Behnke, who hails from Wellesley. Seated in the stern near Jane, and carrying on the traditional Wellesley-Smith rivalry is Miss Mary Booth, native of Brooklyn, who is now busy trying to light a cigarette on less than seven matches. The problem is finally solved by sun-scorched Peg Young who, using knowledge gained from a Purdue-Wellesley education, builds a tent of blankets and overcoats and lights her P. M. on one torch. Leaning over Peg's shoulder is Eunice Kingsley, giving advice on sunburn remedies, derived from experience in the hot sun at Kansas State. Snoozing in the sun on the forward deck is John J. Paull, pioneer from West Virginia, and Washington and Jefferson's most enthusiastic Red Sox fan. Our white-turbaned colleague from Goucher, Margy Hitchcock, sits quietly in her seat, staring out over the water, already looking forward in eager anticipation to the evening's study of specimens to be collected. Engaged in more immediate plans are Dr. Taylor and Dr. Croasdale, sprawled over a map spread out on the deck. They are discussing landing places, the best routes to take, and the all-important question of when and where to eat. The scholarly-looking fellow nearby is Ed Richardson, Mass State, '41, and Graduate Assistant at Rutgers, getting some professional pointers on how to conduct a field trip. Ed, our B.M.O.C., succeeds in carrying on many extra-curricular activities, serving as editor of Botany Class Notes, and Chief Air Raid Warden for the Class. Ed's flying trips to New York City on official Coast Guard business are one of our chief sources of excitement. He returns barging into the midst of our diligent class with wild tales of making it from the Battery to Grand Central in six minutes flat —ending with the familiar call, "Everyone going swimming?"

It is this eager band of botanists now engaged in an intensive study of the aquatic flora of Woods Hole and vicinity. The fresh water groups are now well taken care of, and the class has already turned its attention towards the much more fascinating marine forms. Already students may be seen wading waist-deep in the waters of Nonamesset Island and the rocks of the Inner Harbor, clutching at a bucket with one hand and an elusive Laminaria with the other. Lights may be seen burning late into the night on the second floor of Old Main as feverish phycologists attempt to induce a writhing sprig of Polysiphonia to come to rest on a herbarium sheet, or rush to preserve a blade of fast-fading Fucus. There are also rumors about the laboratory that some algologi have set their alarms for as early as four A. M., to run out to Nobska Point to see the night's accumulation of floating flora.

Very often the class takes all-day field trips on the *Nereis* which compare quite favorably with the much-talked-of picnic held recently by the embryologists. Last week the class enjoyed a cruise along the outer edge of the Elizabeth Islands, and roamed over all of Pasque Island in search of cryptic cryptogams, as well as visiting parts of Naushon which were both picturesque and botanically interesting. The lunch provided by the Mess was most enjoyable, and furnished renewed enthusiasm for the afternoon's work. On Tuesday a trip to Penekese Island furnished an opportunity for much interesting marine study, and many pailsful of representative algae were brought home to find their final resting place in someone's collection or the bottom of a laboratory crock. Between these field trips the class is continuing its study of the Chrysophyta and Pyrrophyta.

Well, that's all for now. —*J. B and E. R.*

PHYSIOLOGY CLASS NOTES

Even though outnumbered by the Embryologists, we had a swell time on our Fourth of July picnic—lobsters and butter and mussels (not the kind of which we took strength—duration curves under Dr. Schiel's tutelage)—which reminds us we miss Dr. Sichel and his peanuts, of course.

By the way, we were sorry that Nat got caught in the draft, not in the currents like we've heard tell about some people.

We've been accused of cheating the paramecia out of some of their ultraviolet rays as we've sat out in the sun with microscopes flanked by exposure meters and eosin-filled Syracuse dishes—this being our week of photobiology under Dr. Giese. All of which led to some misinterpretation of Dr. Fisher's remark when George, having decided to stick to photobiology, was said to be doing "light" work. What George was wisely avoiding was "bubble trouble" (our theme song) with Warburg manometers. To further stymie us the current became alternating in the true sense of the word last Saturday and the Warburg's had to be shimmied by hand.

As a final word may we recommend counting slowly multiplying (or is it dividing—where is our slide rule!) *Arbacia* eggs to get to sleep at night. We got a bit involved in that last sentence, so let that be all. —*E. H., V. L. and E. L.*

DIM-OUT REGULATIONS FOR WOODS HOLE

The Planning Division of Falmouth Public Safety Committee respectfully requests your full cooperation in carrying out the following regulations relative to Dim-out as required by the First Corps Area, U. S. Army.

1. Where exit lights are necessary on porches or outside steps anywhere in Region 7, Cape and Islands, they must be either 6, 7½, or 10 watts each, and installed in or under an opaque shade directing the light downward and allowing no upward light.

2. Windows or openings through which lights would be visible from Buzzards Bay, Cape Cod Bay, and the Atlantic Ocean must be completely darkened.

3. Window shades in homes must be pulled in lighted rooms in all of Region 7 to reduce skyglow. Street lights are on for reasons of highway safety, and where necessary they have been or will be shaded. House lights, however, are useful only to those inside the house—so pull your shades and reduce skyglow. Where ventilation is necessary, shades must be lowered to a point which will prevent direct light from going above the horizontal.

4. Restrictions on auto lights remain the same. Parking lights and 15 miles per hour where lights are visible from Buzzards Bay, Cape Cod Bay, and the ocean side. Down beam is permitted elsewhere, unless ruled otherwise by the Regional Office, or the town Public Safety Committee.

5. Illuminated outdoor signs are not permitted anywhere in the Region.

The Falmouth Public Safety Committee recently stated that since the Dim-out has not been entirely satisfactory to the Army it is absolutely required that these regulations be strictly observed in order to avoid a permanent Blackout which would be very undesirable.

FISHERY FELLOWSHIPS FOR SOUTH AMERICANS

The United States Government is awarding training-in-research fellowships to citizens of an American republic, *other than the United States,* to qualified workers in the following branches of fishery science: Fish culture, agriculture, fishery biology, fishery economics and fishery technology. Persons selected will receive a monthly allowance of $150; in addition all travelling expenses, tuition, medical and infirmary fees, costs of textbooks and rental of any necessary equipment, etc. will be paid. The fellowships are being administered through the Fish and Wildlife Service of the Department of Interior with the cooperation of the State Department.

DEPARTMENT OF SCIENTIFIC APPARATUS

The Department of Scientific Apparatus continues to supply the physical equipment for research at the Laboratory. The number of special pieces of physical or physico-chemical apparatus for loan has been increased during the past few years until now most unexpected problems can be tackled as they arise. The war has, of course, limited the purchase of some types of new equipment this year, but the supply on hand is sufficient to cover most eventualities.

The services of a photographer, Miss Bridgman, and of a glassblower, Mr. Graham, are now available. A machinist will be at the Laboratory for about three weeks during the latter part of July and the early part of August. All those with construction problems requiring careful machining should see Dr. Little in Room 1 of the main brick building as soon as possible.

It is hardly necessary to caution investigators to be extra zealous in their care of instruments this year for most of them can not be replaced.

—E. P. Little

Dr. Kenneth Cooper, who worked at the Laboratory last summer, visited Woods Hole earlier in the summer and is now teaching in the biology department at Princeton University.

Because of war conditions, the Genetics Society of America will not hold a summer meeting this year.

ACTION OF ULTRAVIOLET ON CELLS

(Continued from page 29)

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THE COLLECTING NET

Vol. XVII, No. 3 SATURDAY, AUGUST 1, 1942 Annual Subscription, $1.00 Single Copies, 30 Cents.

FISHERY RESEARCH IN CANADA

DR. A. G. HUNTSMAN

Consulting Director and Editor

The Fisheries Research Board of Canada has evolved in biological fashion through the combined action of its nature and its nurture, and past nurture has played its part in determining the present nature. The Board was born toward the close of the last century, significant forces becoming focussed at a meeting of the British Association for the Advancement of Science at Toronto in 1895. The time of its conception is uncertain, but was more than ten years earlier. The fertilizing agent was the desire of University biologists for means to study aquatic and particularly marine organisms, and this desire fused with a popular belief that science could aid the fisheries, as in extending the system of fish culture that was thought to be refilling the waters with fish.

From its start, the Board has been supported by federal funds and has been associated with the Department of Fisheries. (*Continued on page* 45)

M. B. L. Calendar

TUESDAY, August 4, 8:00 P. M.

Seminar: Dr. Sol Spiegelman: "Differential effects on the mass and time of appearance of regenerants in Tubularia."

Florence Moog: "Some effects of temperature in the regeneration of Tubularia."

Dr. Mordecai Gabriel: "The effect of temperature on vertebral variations in Fundulus heteroclitus."

FRIDAY, August 7, 8:00 P. M.

Lecture: Dr. Selman A. Waksman: "Science in Soviet Russia on the Eve of the World War."

TUESDAY, August 11, 11:30 A. M.

Annual Meeting: Corporation of the Marine Biological Laboratory.

PROTOPLASMIC REORGANIZATION

DR. C. V. TAYLOR

Professor of Biology, Stanford University

Visible activity commonly demarcates the living from the lifeless things of nature, quite as much in the slow growth of plants as in the rapid movements of animals. In some respects, in fact, the elemental nature of vital activity is biologically better illustrated by the growing plant which represents not only an increase in size of its functioning parts, but also the origin and differentiation of those parts and of the organism as a whole.

It is now nearly a commonplace to say that each of all forms of life, whether plant or animal, ameba or man, typically begins its individual existence as a so-called undifferentiated cell which by protoplasmic differentiation or also by cell division, growth and cellular differentiation becomes the full-fledged adult organism characteristic of its particular genus and species.

To understand fundamentally this developmental history of living things, which involves

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CLASS AND STAFF OF THE PHYSIOLOGY COURSE

First Row: G. Osterman, Dr. F. J. Sichel, Dr. K. C. Fisher, Dr. A. C. Giese.
Second Row: Ester Hardenbergh, Virginia Larson, Eva Low, Gertrude Christiansen.
Back Row: J. Stern, Connie Tuttle, Dr. R. T. Kempton, Kit Stevens.

also their evolutionary history, has long been a major task for the ablest minds. Such investigations are the essential counterpart of studies that have equally long had to do with the structure and functions of the adult organism. Any adequate concept of a living organism must accordingly embrace its entire life history, all levels of which obviously have equal importance.

It is helpful, as noted, to identify life with activity but clearly enough that does not suffice. Even the child would ask, "the activity of what?" The activity of a living thing is something unique. No other object in nature at all compares, and yet it is apparent that the elemental constitution of a living thing is the same after its death. The difference, it seems, inheres not in the kind and quantity of the constituent elements but rather in their combinations before and after death ensues. This unique spatial arrangement and integration of the constituents of a living thing is designated its organization. The complexity of that organization has long been recognized but its essential nature remains unknown. This is mainly because all methods of analysis thus far devised disintegrates the very thing or substance to be analysed. Only the residue, including proteins, lipoids, carbohydrates, salts and water, remains. These may be pieced together again in various combinations, some of which exhibit properties similar to some properties of protoplasm but never to all its properties. Evidently nature has produced throughout the eons of time what man in his few centuries of advancing knowledge cannot reproduce. Yet no one would deny that tremendous advancement has been made, nor would anyone seriously doubt the prospects in this direction for future generations. It is well to bear in mind that the advancement of science is not by one man or any group of men of one generation; it is the product of successive generations.

It is now evident that whatever the essential nature of protoplasmic organization is, that organization is never static. It represents activity, continuous activity so long as life continues. And if the biogenetic law is valid, the protoplasm of all things living today is, through the germinal line, as old as life itself and has that long been continuously active. This vast disparity between the continuous vital capacity of the germinal line and the discontinuous capacity of its offshoots, or individual organisms, has engrossed the minds of many investigators, including Weissmann, who consequently formulated a half century ago his Germ Plasm theory. This theory postulated two kinds of protoplasm, viz., germ plasm and soma plasm. The former gave rise to the latter but remained undifferentiated. The soma plasm through its differentiation into tissue cells that compose the organs and organ systems of the individual organism thereby ceased to reproduce, became

specialized and so performed specific functions until literally worn out so that death was the inevitable and wholly natural consequence. Weissmann recognized that some organisms were exceptions. These were the micro-organisms, including, e.g., Paramecium. When it was discovered that the micronucleus of this and other ciliates persisted during and following conjugation, whereas the macronucleus disintegrated and was replaced by one of the resulting daughters of the divided micronucleus, Weissmann identified the latter as the germ plasm and the former, or macronucleus, as the soma plasm. The cytoplasm, however, which obviously also continued from generation to generation, was largely left out of account except that it was supposedly maintained by the omnipresent micronucleus. Theorists are, of course, wont to explain exceptions to their theory.

The germ plasm doctrine, in its original formulation, has been variously discountenanced and is so today, but the facts it incorporated remain and so give merit to the theory in a modified form. As previously noted, individual organisms typically originate from so-called undifferentiated, or primordial cells, and it is *generally* true that in becoming fully differentiated, cells cease to divide.

There remains, however, another well-established observation that some highly differentiated cells, including ciliates, flagellates and ciliated epithelial cells undergo a process of *protoplasmic reorganization.* This occurs with each cell division. It involves the resorption of all cilia or flagella, and other visibly differentiated structures and the outgrowth of new cilia and other structures in the resulting daughter cells. In a number of the ciliates thus investigated it has been found that this process of resorption and new outgrowth occurs also during conjugation, and during encystment and regeneration.

In the ciliate, *Colpoda duodenaria,* a detailed study of its reorganization has been made during fission and encystment. There it was found that its internal fibrillar complex as well as its cilia and membranelles were completely resorbed. Moreover, in the induced cysts, not only was this resorption of cytoplasmic organelles evident, but also the nuclei underwent changes which strikingly simulated the changes (especially in the macronucleus) during binary fission.

What the real significance of these reorganization changes may be remains for further investigations on this and other protozoa and on suitable tissue cells of multicellular organisms. It would appear, however, that the process of protoplasmic reorganization is truly deep-seated and may involve the entire hyaline protoplasm and nucleus.

It now seems not unlikely that these changes thus described for various ciliates and flagellates may eventually be found to be comparable with the well known cytoplasmic and nuclear changes that ensue during mitosis in the higher organisms. The appearance and disappearance of the amphiaster, the nuclear membrane and the chromosomes suggest this possible parallelism. One might reasonably speculate further to include similar changes in the structural framework of the elastic cytoplasm.

In this connection some exceedingly interesting findings have been reported during the past few years on the behavior of physical systems other than protoplasm. These include the phenomena of coacervation, as reported especially by Bungenberg de Jong, and of tactoid formation as studied by Bernal, Fankucken et al. An extensive theoretical treatment of coacervates and tactoids (ovoid structures with pointed ends) was recently published by Langmuir who would regard the behavior and the forces involved in the two phenomena as quite comparable. In each phenomenon, the dispersed particles, whether spherical or elongate, would come to approach one another through thermal agitation. Within a given range (1000 Å for rod-shaped particles) an electrostatic field between the particles would appear which would not only tend to draw the particles together, but would also draw between them water molecules and various ions in solution. Intervention of the water and the ions would serve to keep the particles separated. If the particles were of sufficient size such that their thermal energy was less than the energy of equilibrium, an equilibrium system would be realized. Thus vacuoles, among other structures, were formed.

Using tobacco mosaic virus for the dispersed phase, Bernal and Fankucken observed that when streaming through a capillary the rod-like virus particles all oriented parallel to the current. In suitable concentration and at a given pH the particles aggregated to form numerous tactoids, conforming to the forces acting tangentially and acting at right angles to the long axis of the particles and the resulting tactoid. Upon shaking the container the many tactoids came into contact and arranged themselves so as to form a continuous network throughout the medium, thereby producing

"The Collecting Net" was entered as second-class matter July 11, 1935, at the Post Office at Woods Hole, Mass., under the Act of March 3, 1879, and was re-entered on July 23, 1938. It is devoted to the scientific work at marine biological laboratories. It is published bi-weekly between July 1 and September 1 from Woods Hole, and is printed at The Darwin Press, New Bedford, Mass. Its editorial offices are situated in Woods Hole, Mass. Single copies, 30c; subscription, $1.00.

a gel whose elastic and other properties were conspicuous. The gelation process was reversible.

It seems altogether probable that this striking behavior in reversible tactoid and net-work structures may have its counterpart in the hyaline protoplasm. If it can be assumed, as appears probable, that elongate particles such as the protein molecules or micelles are invariable constituents of the dispersed phase of the hyaline protoplasm (omitting the grosser microscopic inclusions), then certainly the forces operating in an inanimate colloid system like that of the tobacco mosaic virus would obtain also in the hyaline protoplasm. Accordingly, tactoid formation might be expected, momentarily at least, followed by a linear aggregation of the tactoids to form a net-work throughout all or part of the hyaloplasm. Thus gelation would result, giving to the hyaloplasm its characteristic property of elasticity. Conversely should a suitable chemical change, locally or generally ensue, such as a shift in the pH, a corresponding local or general reversal to the more fluid sol state could be expected.

Various extensive studies here at the Marine Biological Laboratory by Chambers, Heilbrunn, Harvey and others have provided many examples of reversible gelation changes in protoplasm. Some years ago Chambers showed by methods of micromanipulation that the amphiaster of dividing marine ova was an elastic gelated structure which could be mechanically induced to disappear. Not long thereafter, however, it might reappear, following which cell division went on normally to completion. Also, by centrifuging Arbacia eggs, Heilbrunn demonstrated and measured viscosity changes during maturation and fertilization, the immature ovum having a measurably higher viscosity. It was further shown by micromanipulation (Chambers) that following breakdown of the germinal vesicle a medullary portion of the cytoplasm underwent solation, leaving a cortical gelated area some 4 or 5μ in thickness. Harvey observed that during the centrifuging of Arbacia eggs in an optical centrifuge some of the granular inclusions showed jerky migrations indicating a structural cytoplasm. It would thus appear that protoplasmic viscosity is a structural viscosity subject to reversible sol-gel transformations. This is borne out also by the results of studies by Seifriz, Frey-Wyssling, Heilbronn and others. Might we not, therefore, suppose as a working hypothesis that the entire cell is thereby reversibly integrated and that the rod-like protein constituents which form this net-work may also be linked with prosthetic groups, forming enzymes, and with lipoids, carbohydrates, salts and water, leaving a large part of the known water and its solutes in a cell as the essential dispersion medium? Such a view approximates closely the well-known concept of the cell as a kind of multimolecule, subject to regional gelation changes which would allow for the formation of vacuoles, of fibrils and of amphiasters, but still maintaining its indispensible unity.

At the present state of our knowledge further speculation would be inadvisable and would doubtless be viewed as unduly biased. So long as facts and interpretation are properly compartmentalized, however, it might eventually prove helpful, as a closing paragraph to this discussion, to refer again to the long-standing discrepancy previously mentioned between the "immortal germ plasm" of a given phylum and the "mortal soma plasm" of the multicellular organism. From various regeneration experiments covering many decades it would appear that metazoan ontogeny proceeds toward a fixed and irreversible state of differentiation. In the lower phyla and during the early stages of ontogeny in the higher phyla, a capacity to dedifferentiate is evident in the results of egg-fragment studies, of blastomere isolations and of early and later regenerative phenomena varying according to the species and depending upon the tissues or organs concerned in the individual organisms. Thus the *tendency* in metazoan ontogeny is apparently toward irreversibility which eventuates in degeneration and death. Unicellular organisms, on the contrary, retaining the capacity of dedifferentiation and redifferentiation, i.e., the capacity of protoplasmic reorganization, may be regarded as potentially immortal beings.

Of what efficacy to this end, however, can the phenomenon of protoplasmic reorganization be? As one of the various factors, it might be suggested that if in the last analysis we may regard dedifferentiation as physically a dispersion process involving the separation, say, of the protein molecules or micelles which with gelation formed the evident hyaloplasmic frame-work, such dispersion would, it appears, necessarily precede spindle formation and likewise cell division. If with time, however, these frame-work molecules came gradually to be inseparably fixed, obviously cell division could not ensue. Chambers has noted that tissue cells, such as of muscle and nerve, which ordinarily do not divide, are apparently in a continuously gelated state. Of course this incapacity for further cell division might not of itself affect the continuity of vital activity, but it is conceivable that gradually increasing fixation of molecular structure might involve the enzyme systems of that structure and so indirectly mark a decline in normal functional activity. Accordingly, periodic reorganization of the protoplasm may be the visible manifestation of deep-seated recurrent changes that insure the continuity of life.

FISHERY RESEARCH IN CANADA

(Continued from page 41)

It was incorporated by Act of Parliament in 1912, when fourteen years old, and since then has been an independent body under the Minister of Fisheries. Its development is to some extent reflected in the changes that have been made in its name, —Board of Management of the Marine Biological Station of Canada, Board of Directors of the Biological Stations of Canada, Biological Board of Canada (1912), and Fisheries Research Board of Canada (1938).

The founders of the Board who served as its Chairman, or Vice-Chairman during the first twenty-eight years of its existence were: the Englishman (trained at the Scottish Gatty Marine Station under Professor W. C. McIntosh), Dr. E. E. Prince, Dominion Commissioner of Fisheries; the Scotchman, Professor R. Ramsay Wright, of the University of Toronto; and the Canadians, Professor A. B. Macallum of the University of Toronto, and Professor A. P. Knight, of Queen's University. Coëval with these was the succeeding chairman, the Canadian, Professor J. P. McMurrich of the University of Toronto, who became a member in 1912, after his return to Canada from a lengthy career in universities in the United States, with long experience at United States marine laboratories beginning at the Chesapeake Zoological Laboratory, Beaufort, N. C., in 1881. He was followed by the present Chairman, the Englishman, Professor A. T. Cameron of the University of Manitoba.

The work began in a movable laboratory at St. Andrews, New Brunswick, on the Atlantic coast in 1899. The Georgian Bay Biological Station on the Great Lakes was started in 1902, but ceased to function after thirteen years. A Pacific Biological Station was established near Nanaimo, Vancouver Island, in 1908. The Atlantic Biological Station, after trial at five different places, returned to its starting point and became permanently established at St. Andrews in 1907. The assumption of control of their fisheries first by the Province of Ontario in 1906 and subsequently by the Province of Quebec and the Prairie Provinces, has tended to limit the work of the Board to the Maritime Provinces and British Columbia. For a time, however, biological investigations were carried out in Ontario and in the Prairies, and recently the Board established a Fisheries Experimental Station in the Gaspé peninsula of Quebec.

From the start, the Board has attempted to combine thoroughly scientific fundamental investigation with the practical, as instanced in its first two publications by studies of the structure of the fins of the mackerel shark, and of the effects of sawdust and explosives on fish life. The important local herring (sardine) and clam fisheries were investigated at St. Andrews in 1899. When the Station was at Malpeque, Prince Edward Island, in 1903 and 1904, most of the effort was devoted to study of the famous Malpeque oysters, which suffered practical extinction in 1915 and 1916, presumably from disease brought in with seed oysters from Long Island Sound. This oyster fishery has been restored in recent years, following the establishment in 1930 of the Prince Edward Island Marine Station at Ellerslie on Malpeque Bay.

During the war of 1914-18, there was the stimulus of changing economic needs. Professor Macallum, who became later the first head of the Canadian Research Council, stimulated investigations (beginning in 1915) of the smoking of fish and of bacterial decomposition of fish, that were carried out at the Atlantic Biological Station. Inedible frozen fish from Canada, served to the troops in France, resulted in investigations of fish freezing at the same Station. The members had all been scientists, but in 1924 the Board was enlarged to include an administrator from the Department of Fisheries as well as a representative of the industry from each coast. It now consists of nine scientists from various universities, two administrators from the Department of Fisheries, and from each coast two representatives of the industry. This tripartite constitution has been extremely effective for that fusion of varied points of view that can bring about success in the work of the Board. An immediate outcome was the establishment in 1924 on the Atlantic coast at Halifax of a Fisheries Experimental Station for the investigation of the methods of preserving or otherwise handling the fish. In 1925, a similar station was established on the Pacific coast at Prince Rupert.

At first the work was carried out entirely by volunteers, scientists from various universities that were ready to investigate during the summer vacation period, if their expenses were met by the Board. Consequently, the work surged or receded from year to year as interest rose or flagged. Only in 1912 was the first scientist (Dr. C. McLean Fraser) employed on a yearly basis to take charge as Curator of the Pacific Biological Station. Pressure for solution of practical problems resulted in the development of a permanent staff for each station, particularly during the boom period of the late twenties, and after the Report of the Royal Commission on Maritime Fisheries of 1928. Full development of a permanent staff resulted in vir-

tual elimination of the system of volunteer investigators. However, scientists from the universities are employed each summer as Research Assistants.

Facilities for investigators, who wish to gain experience or to conduct investigations of their own, continue to be available at the Board's Stations, particularly those at St. Andrews and Nanaimo. The demand for such by Canadians has not been great, perhaps because the excellent facilities in the marine and lake laboratories of the United States have been freely available to Canadians. In the boom period, the Canadian Government provided funds to build a marine laboratory for Dalhousie University at Halifax, which operated for a couple of years under the Board's supervision. When, with changed personnel, it ceased operation, the Board explored the possibilities of its being used by eastern Canadian universities in general, but there was too little interest shown to justify any action. Jointly with the National Research Council of Canada, the Board sponsors the National Committee on Fish Culture and the Canadian Committee on Oceanography, whose development is being held in abeyance during the war. They are intended to forward or initiate investigations in those fields.

For those that like figures: The Board operates six Stations, two on the Pacific coast and four on the Atlantic, of which half are for marine biological work, and half for the problems in fish handling. It has a permanent staff of 50 scientists and has an annual budget of about $250,000. It has five periodical publications: Annual Report; Bulletins (some are popular and some are technical); Journal (for strictly scientific articles); Atlantic Progress Reports; and Pacific Progress Reports. It also has started Canadian Atlantic Fauna and Canadian Pacific Fauna.

Like medicine and agriculture the fisheries present a great variety of biological problems, from those that are simple to those that will continue to baffle us for many years to come. The comparative novelty of marine life, its extraordinary variety, and the exceptional difficulties that its investigation entails have been particularly intriguing to biologists. These difficulties are doubtless responsible for the fact that the fisheries lag behind medicine and agriculture in practical results from investigations. This has provided a supreme challenge to investigators. The hatching and planting of young fish has been carried out on a large scale in both the United States and Canada for more than sixty years, yet no one yet knows that it has been effective except for introduction into barren waters. The oyster, a mollusk attached to the bottom, has been cultured successfully. No greater success has been attained with the freely moving lobster than with the true fishes. Fundamental knowledge in an unknown number of directions is doubtless necessary for solution of the problems involved. In part, the problems can be realized only by the scientists themselves making practical experiments.

Failing abundance has been the frequently reiterated complaint of fishermen as the human population of North America increased. The problem of how to have more fish is to be solved by knowledge of the factors limiting abundance. Little thinking goes beyond the rather obvious factors —enemies, disease and food. Taxonomists, in studying distribution of species, recognize vaguely that temperature, light, humidity or salinity and other features of the environment are limiting, but the varied action even of temperature has been little elucidated.

The idea that decreased catches are due to overfishing has resulted in an increasing amount of restrictive legislation and has established the belief that it is not only unnecessary but undesirable to aid the fishermen to catch more fish. As might be expected under these circumstances, the problem of the capture of fish has from the scientific standpoint scarcely been touched. But there are many situations where the fisherman needs to be helped, if he is to make a living, and where the evidence is against there being excessive fishing. This holds in the case of the high-priced salmon that can be so easily eliminated at river mouths as well as in the case of the low-priced and often enormously abundant herring that in the eighteen sixties Huxley concluded could not be overfished. For the fisherman, the first question is,—where are the fish; and the second,—how can they be caught. Fish behaviour in movement and in taking bait is the subject for study, and of this we know very little scientifically.

The real problems of the fisheries are only beginning to be solved by the work of the Board. More and more, however, the general investigations of particular fisheries are leading to quite precise definition of problems so that effort can be concentrated in the best directions. There is frequent revelation of the lack of essential fundamental knowledge and the personnel available can remedy this lack but slightly. This gives great scope for university investigators who happen to have or may develop interest and vision in the subjects in question.

Let me illustrate for the salmon the basic biological problems that arise when trying to deal effectively with varied locally and temporarily important aspects of the all-inclusive economic fishery question—how can we get more fish with less work?

What determines sexual maturity? The salmon may spawn at the end of its first year of life while a parr (larval stage?), or only after from one to eight years as a parr, and from one to four years

after transformation into a smolt and migration to the sea. It may grow very slowly, fail to spawn and remain many years as a parr, or it may grow rapidly at first, spawn repeatedly, and also remain many years as a parr, becoming exceptionally large for that stage.

How does a salmon that has migrated to sea get back (if it does get back) to the stream where it lived as a parr? On return from the sea as grilse, salmon that had been distinctly marked when descending two branches of a river as smolts, showed a definite tendency at the fork to take the branch from which they had come, but on the average 20% of them took the other branch. A salmon, marked when descending as a smolt the Margaree River on the inner coast of Cape Breton island, was, after two years in the sea, caught and tagged on the outer coast of Newfoundland in June, and then was caught in its river in September. Salmon are found concentrated where there is strong admixture of river water in the sea.

How does temperature affect fish movement? For a given stimulus a salmon moves farthest somewhere around 13° C., and progressively less far as the temperature is raised or lowered from this vicinity. Around 25° C. it becomes quite active.

How does high temperature cause death? Salmon have been observed to enter and die in a stream with a temperature of 29.5° C. They lost their sensitivity to light and came in full sunlight to the surface so that parts of their fins were out of water.

How does a salmon become able to endure sea water? As a parr it cannot, but as a smolt it can. On returning to fresh water to spawn, it in part returns to the parr condition. The mortality of salmon that descend to the sea after spawning is very high.

THE ACTION OF NARCOTICS ON THE OXYGEN CONSUMPTION OF FROG MUSCLE

Joseph R. Stern and Dr. Kenneth C. Fisher
Department of Zoology, University of Toronto

The effect of narcotics on the oxygen consumption of various cells can be interpreted most easily by assuming that the narcotic has two distinct sites of action in the cell. (c. f. Fisher and Stern, *J. Cell. and Comp. Physiol.*, 1942). These are characterized by different sensitivities to the narcotic. It is implied, then, that the total oxygen consumption is the overall result of the activities of two discrete respiratory systems. In the cells which have been examined cell division is apparently made impossible by complete inhibition of the more sensitive of these two systems. That system has therefore been referred to as the activity system.

Stannard (*Am. Jour. Physiol.*, 1939; 1942) has observed that the oxygen consumption of stimulated frog muscle is inhibited by azide but that a part of the respiration is not affected by this poison. Since the oxygen consumption of unstimulated resting muscle is not affected by azide, Stannard concludes that the oxidative metabolism initiated by the activity of contraction is mediated by a respiratory chain different from that operating in the resting muscle and superimposed upon it. In general, these findings are very similar to the conclusions drawn from the narcotic experiments referred to above. We considered it of interest therefore to determine whether Stannard's conclusions would also follow from observations with narcotics.

Isolated intact frog muscles were prepared and used in the manner described by Stannard. In order to obtain constant respiratory rates resting and caffeinized muscles were used, but not electrically stimulated ones. When any of the narcotics used is dumped into the medium surrounding the muscles, the rate of oxygen uptake declines for some ten minutes and reaches a lower level which is well-maintained for at least two hours. This rate of respiration is termed the inhibition level and will be designated by U. The difference between this level and the normal uninhibited respiratory rate is termed the inhibited respiration and will be designated by I.

The simplest assumption that one can make is that the narcotic combines physically or chemically with a single catalyst to whose concentration the respiratory rate is directly proportional. If this assumption is valid, the law of mass action requires that

$$\log \frac{U}{I} = \log K - a \log [N]$$

where "a" and "K" are constants while [N] is the inhibitor concentration. If this formulation adequately describes the reaction then a plot of log U/I against log [N] should yield a straight line from which the values of "a" and "K" can be obtained.

The experimental data for the action of butyl carbonate and of chloretone on the resting muscle respiration conforms to a straight line when the above plot is made. It is therefore sufficient to postulate here that only a single site of narcotic action exists. The plot for butyl carbonate on active (i.e., caffeinized) muscle closely approximates two intersecting straight lines. These can be predicted theoretically by assuming that there are now two sites of narcotic action.

Chloretone on the active preparation gives a straight line as it does in the resting condition. However, the value of "a" is significantly different from that in the resting preparation. Moreover this respiration is more sensitive to chloretone. The first definite indication of inhibition occurring at a concentration only one-third of that causing a similar degree of inhibition of the resting preparation. It can be shown that the addition of a new system to the one present in resting muscle, thus making two distinct sites of narcotic action, could result in the straight line found with the caffeinized muscle. This interpretation seems at present a better one than the postulation of some unknown modification of a single site giving rise to the change in "a" and in sensitivity.

Preliminary observations with luminal suggest that the resting respiration is not affected by concentrations as great at 1%. The caffeinized respiration, however, is very sensitive to such ranges of concentration and the data indicate in this case that the maximum inhibition obtainable leaves uninhibited a fraction of the total oxygen consumption whose absolute value corresponds well with that of the resting muscle.

It appears, therefore, that the fractionation of the oxidative metabolism of the active preparation first demonstrated by Stannard on the basis of azide sensitivity is also seen in these new experiments with narcotics.

ON THE PHYSIOLOGICAL MECHANISM OF TEMPERATURE "SELECTION" BY FISH

Dr. Kennetii C. Fisher and Grace Workman Scott
Department of Zoology, University of Toronto

It is now well established for most organisms that when free to move in a gradient of temperature, they tend to congregate in a definite narrow range of the temperatures available to them. This behavior is seen with single individuals as well as with populations. It has been called temperature preference or temperature "selection".

The physiological properties which operate to confine organisms in this way are imperfectly understood. It is apparent upon gross examination in trout and salmon fingerlings, and in frog tadpoles that the congregation in a given area does not result from a cessation of movement while in that area. Temperature selection must then be an *active* process and the factors concerned must function in the moving organism. It follows that the sequence of movements which takes the organism to the selected region in the first place, and which then holds it there, must be capable of description in terms of (1) the length and (2) the direction of the individual "darts" made by the animal. Since these are the only significant variables, the immediate mechanism of the selection must be sought in terms of some effect of temperature on either one or both of them.

Elson (*Journal of the Fisheries Research Board of Canada*, 1942) at Toronto has found that the distance which a trout travels in response to an electrical stimulus depends upon temperature. In general, the distance travelled is a maximum at about 10° C. Thus temperature does affect one of the two factors through which the selection is brought about.

The temperature selected by this fish we find to be also of the order of 10° C. It has been possible to establish the practical identity of the selected temperature with the temperature of maximum response in two other organisms as well, salmon and frog tadpoles. It seemed likely that the effect of temperature on the distance moved might therefore be related to the selection of temperature.

Before the observations at different constant temperatures can be considered to be of significance in the behavior of an organism moving in a gradient of temperature, it must be shown that the animal in question modifies its movement in the gradient in accord with the different temperatures experienced. To test this point animals photographed sixty-four times a second as they moved in response to an electrical stimulus either at constant temperature or in a temperature gradient. The pictures indicate clearly that the motion is indeed modulated in accord with the environmental temperature as the organism moves through the gradient. A single dart is completed in a very few seconds so that the modulation must be mediated through sense organs and the central nervous system.

The simplest modification of a dart which carries the animal through several temperatures will be one based upon the observations at constant temperatures. So far as our data goes, this prediction is born out rather completely by the photographs of the movements in the gradient. It can be stated in this way: In general, all darts made in the direction of the temperature of maximum response will be longer than those made in any other direction. If now the direction in which any given dart commences is determined by chance, it follows that the result of a series of darts will be a net movement towards the temperature at which the maximum response occurs. The organism should in fact "select" or "prefer" that temperature, and this, as pointed out earlier, they appear to do.

It is concluded, therefore, that temperature selection is probably due in the first instance to the fact that the distance moved in response to a stimulus is a maximum at the selected temperature.

THE INVERTEBRATE ZOOLOGY COURSE AT WOODS HOLE IN 1942

Dr. Allyn J. Waterman
Associate Professor of Biology, Williams College; Director of the Course

This course is designed for those who have had some previous training in zoölogy and more especially for those having a professional interest in the subject. Its purpose is to familiarize students with the taxonomy, anatomy and physiology of representative examples of the local marine invertebrates, with the habits, habitats and general ecological relations of these animals and to furnish opportunity for the study of fresh material. Work on the Chordata is limited to the Protochordata.

In order that students may become familiar with the conditions under which invertebrates of the littoral zone of the sea normally live, a series of field trips is arranged to points of interest such as rocky shores, mud- and sand-flats, wharf piles, protected inlets and to open water where dredge and tow net may be used. Tow is studied in the laboratory. On these trips, taxonomy, ecology, and animal distribution are emphasized. On return to the laboratory after each field trip, the animals collected and brought back in the *Ark* are checked and an ecological report of the trip written by each student. This report includes the drawing of a rough map of the region visited to show, among other things, the different types and extent of the habitats, the chief animal types of each habitat, and their relative abundance and something of the distribution of some of the more common animals. Beginning with this summer a record will be compiled by the members of the staff from these reports, from the record kept by the *Recording Angel* of each team and from their own experience of each trip taken. In this way it is hoped that a body of information may be accumulated which will be of future interest. On these trips the student will also become acquainted with the various methods employed in collecting. In his report, check-list and laboratory records he will carry away with him a record of the summer's experiences. Particular emphasis is laid upon the field work since the animals cannot be adequately understood when considered apart from their surroundings and since many of the broader problems connected with marine zoology can be appreciated only after intimate study of conditions as they exist in nature.

While descriptive zoology, taxonomy, physiology and observations in the field constitute the backbone of the course, stress is also placed upon particular current problems and results of experimental investigations on invertebrate animals. This is amplified by occasional lectures held in the laboratory and given by members of the staff and guests. These lectures have been a feature of the course for many years. Several evening seminars are planned for the informal discussion of topics dealing with the study of invertebrates and will be held in the laboratory. It is hoped that such topics as those dealing with the invertebrate heart, nervous system, endocrine glands, color changes, etc. may be taken up. The first of these seminars was given by Professor C. V. Taylor, Stanford University, on the subjects "Invertebrate Vs. Vertebrate Structure" and on "Cytoplasmic Reorganization." Dr. Libbie Hyman expects to come to Woods Hole for a few days and will speak to the class.

Certain changes have been made in the staff, and due to the war emergency, it has been reduced to seven members. The junior instructor rank has been abolished, which is a return to the staff organization of many years ago. Under this plan the laboratory assisting is divided among the instructors. Dr. Gilbert, of Cornell University, and Dr. Jones, of the College of William and Mary, resigned because of the accelerated teaching programs of these institutions. Dr. MacGinitie, of the William G. Kerckhoff Marine Laboratory, was unable to come East this summer. Dr. Smith, of Harvard University, is engaged in a defense project, and Dr. Tartar, of the University of Vermont, is in government service. The staff now consists of: Dr. J. B. Buck, assistant professor of zoology, University of Rochester (Bryozoa, Annelida); Mr. M. D. Burkenroad, assistant curator, Bingham Oceanographic Foundation, Yale (Coelenterata); Dr. Willis Hewatt, professor of biology, Texas Christian University (Echinodermata); Dr. W. E. Martin, associate professor of zoology, DePauw University (Arthropoda); Dr. N. T. Mattox, assistant professor of zoology, Miami University (Porifera, Mollusca); Dr. R. W. Wilhelmi, instructor of zoology, University of Missouri (Platyhelminthes, Nemathelminthes); and the undersigned (Protozoa, Protochordata). The assistant is Miss Ruth Merwin of the University of Chicago. The special lectures of the staff this summer will be given by Mr. Burkenroad on "Marine Zoology," Dr. Hewatt on "Marine Ecology," and by Dr. Wilhelmi on "Phylogeny." Considering the conditions imposed by the existing war emergency, the enrollment in the course may be said to be satisfactory; there are 34 students representing 30 institutions. Mr. Enrique Avila, Campania Administradora del Guano, Peru is expected to join the class later.

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Judy Woodring and Jane Woodring.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

BIOLOGISTS AND THE WAR

Last Tuesday evening a group of about fifteen of the leading biologists in Woods Hole gathered in the Board room of the Marine Biological Laboratory to discuss the part biologists might play in the prosecution of the war. Dr. Charles Packard presided, the discussion being opened by Dr. C. V. Taylor of Stanford University. Among the problems taken up were the relation of the undergraduate and graduate student to the Selective Service Act and the machinery for placing enlisted and drafted biologists in jobs where their special training could be utilized to best advantage. This was followed by a consideration of the question as to whether biologists should devote themselves primarily to the immediate prosecution of the war or to a long-range program extending into the reconstruction period after it is terminated. Dr. Galtsoff presented effective arguments for emphasizing the latter, but the concensus of opinion seemed to be that more immediate matters came first.

The group voted that a committee should be appointed to formulate more specifically the problems facing the biologist—and that the group should assemble again to consider them more formally. The members of the committee will be announced shortly.

DR. WOODRUFF'S PROLIFIC PROTOZOA

An animal that has produced 21,000 generations of offspring and yet is still alive is celebrating its 35th anniversary in the Osborn Zoological Laboratory of Yale University.

The animal in question is a race of the microscopic water-dweller known as paramecium or slipper-animalcule. Because this particular race was started on its career of biological immortality by Prof. Lorande Loss Woodruff, it has come to be known as the Woodruff race.

Paramecium is able to reproduce itself indefinitely by simply dividing in two, without any sex process. Each of the two parts rapidly grows again to original size, so that each can claim to be the original individual; also, barring accidents, this continuously dividing-and-multiplying individual never dies. So that we arrive at the paradoxical situation of having millions of microscopic animals, each with as good a claim as any of the others to being the founder of the line, and all of them 21,000 generations old without having experienced death.

Of course, the great majority of the offspring of the Woodruff paramecium race have been discarded and destroyed. If all had been kept, and food enough could have been provided, the race would in the first five years have packed all known space, out to the farthest stars, with a solid mass of paramecia.

This race of microörganisms has passed through 21,000 of its generations in little more than the time reckoned as one human generation. In human terms, 21,000 generations would be 630,000 years—a period going back to the haziest conjectural beginnings of the most primitive prehistoric human beings.—*Science Service.*

On July 29 there were 140 investigators working at the Marine Biological Laboratory; the corresponding day of the previous year there were 284. A comparison of the number of investigators for four years on July 29 is given below:

1939	303	1941	284
1940	297	1942	140

CURRENTS IN THE HOLE

At the following hours (Eastern War Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
August 1	7:55	8:19
August 2	8:44	9:13
August 3	9:36	10:08
August 4	10:29	11:06
August 5	11:23	
August 6	12:04	12:18
August 7	1:00	1:11
August 8	1:51	2:00
August 9	2:37	2:47
August 10	3:20	3:30
August 11	4:02	4:12
August 12	4:42	4:54
August 13	5:21	5:36
August 14	6:01	6:18
August 15	6:43	7:03
August 16	7:26	7:49
August 17	8:11	8:39
August 18	9:01	9:34

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

The annual meeting of the members and trustees of the Corporation of the Marine Biological Laboratory will be held in the auditorium of the Laboratory on Tuesday, August 11.

The absence of so many regular workers at the Marine Biological Laboratory has brought about the appointment of an Interim Executive Committee made up of the following members: Dr. C. Packard, Lawrason Riggs, Jr., *ex officio*, Dr. A. C. Redfield, Dr. C. W. Metz, Dr. S. O. Mast, Dr. M. H. Jacobs and Dr. D. Brown. The recently appointed Nominating Committee for new trustees consists of Dr. L. Irving, Dr. S. C. Brooks, Dr. W. R. Taylor, Mrs. E. N. Harvey and Dr. D. A. Marsland.

Dr. Josepii C. Hinsey, professor and head of the Department of Anatomy has been appointed dean of the Cornell University Medical College. In 1936 he came to Cornell from Washington University, St. Louis, assuming the headship of the Department of Physiology, which he held for three years.

Dr. A. W. Pollister has been promoted from assistant to associate professor of zoology at Columbia University. He recently returned from a year's leave of absence which he utilized at the California Institute of Technology.

Dr. Daniel Merryman, of the department of zoology at Yale University, has been promoted from instructor to assistant professor. He also has been appointed director of the Bingham Oceanographic Laboratory.

The Department of Zoology of Columbia University is planning a fiftieth anniversary celebration which will be held in October.

Albert James Stunkard (Mickey), for the past two years the ground-keeper of the M.B.L. Tennis Club, entered the College of Physicians and Surgeons of Columbia University as a beginning student early in July. His parents, Dr. and Mrs. Horace W. Stunkard, came to Woods Hole July 22 to spend the summer; their daughter, Eunice, came with them and will be here until Wellesley opens at the end of August.

The following men at Johns Hopkins who have been working with Professor S. O. Mast are now with the United States Army in the School of Aviation Medicine at Randolph Field, Texas: Dr. Charles G. Wilbur, who took the invertebrate zoology course last summer; Dr. John P. Marburger, assistant professor of science at Blue Ridge College, Maryland; and Dr. James Dent, research assistant to Dr. Mast.

L. Robinson Hyde, radio-therapist at Philips Exeter Academy, is the new operator in the Radiology Department of the Marine Biological Laboratory.

Dr and Mrs. John Buck arrived at Woods Hole recently with their four months old daughter. Dr. Buck is teaching in the invertebrate course at the Laboratory this summer.

Members of the Department of Zoology of the University of Pennsylvania recently rowed over to Devil's Foot Island for their annual picnic.

Mrs. Dayton Carritt, who has taught biology at Smith College, has taken over the junior laboratory course at the Science School in the absence of Mr. McAffie.

Dr. Donald J. Zinn, a lieutenant in the American Air Force, is stationed at the School of Aviation Medicine at Randolph Field, Texas. Also there are Dr. Lou Kleinholz and Eugene Copeland.

Drs. C. V. Taylor and Paul Galtsoff are leaving Woods Hole on Saturday to attend a meeting of the War Committee of the Division of Biology and Agriculture of the National Research Council on Sunday morning, August 2. The Committee is meeting to discuss problems dealing with the biological aspects of the war effort. Dr. Galtsoff will return to Woods Hole on Tuesday, but Dr. Taylor is returning to continue his work at Stanford University. On the way, however, the latter will talk with biologists in Chicago and New Orleans concerning the place of biologists in the present emergency and its aftermath.

Mr. Alfred H. Woodcock, of the Woods Hole Oceanographic Institution, recently returned from a trip to Chicago, where he investigated the possibilities of making a study of the transfer of heat and water across the surface waters of southern Lake Michigan. Preliminary steps are now in progress. The work will be done in cooperation with Dr. C. G. Rossby of the Meteorological Institute, University of Chicago. Some additional work will also be done in the University's new hydro-dynamics laboratory. Mr. Woodcock left again for Chicago last Wednesday and will be working at the Institute for a month or more.

Dr. E. P. Little, manager of the Apparatus Department of the M.B.L., purchased and is now living in the house known as the "Crossways Cottage" on the northwest corner of North and West Streets. The house formerly belonged to Professor Warren of Princeton University and was moved from its original site near the Breakwater Hotel a number of years ago.

SUPPLEMENTARY DIRECTORY FOR 1942

MARINE BIOLOGICAL LABORATORY

INVESTIGATORS

Atkinson, Lenette R. res. asst. biol. Amherst. Br 223.
Barber, Ava J. California. Br 322.
Beck, L. V. instr. phys. Hahnemann Med. (Philadelphia). Lib.
Boche, R. D. instr. zool. Pennsylvania. Lib.
Brill, E. R. fel. biol. Harvard. Br 217m.
Buck, J. B. asst. prof. zool. Rochester. OM 26.
Brummer, D. L. New York Med. Br 315.
Child, Ruth C. asst. prof. English. Wellesley. Lib.
Cole, Edith asst. biol.
Cook, Elizabeth J. asst. biochem. Harvard. Br 231.
Conklin, E. G. prof. biol. Princeton. Br 321.
Curtis, W. C. prof. zool. Missouri. Br 335.
Diamond, L. K. assoc. pediatrics, Harvard Med. Lib.
Fisher, K. C. asst. prof. phys. zool. Toronto. phys. lab.
Frey, D. G. jr. aquatic biol. U. S. Fish & Wildlife. Br 332.
Grand, C. G. res. assoc. biol. New York. Br 334.
Gurewich, V. asst. attending physician. Bellevue Hospital. Br 223.
Haugaard, G. asst. Carlsburg Lab. Denmark. Br 125.
Hamilton, Pauline G. res. asst. zool. Pennsylvania. Br 217c.
Harnly, M. H. assoc. prof. biol. New York. Br 221.
Harris, M. Br 221.
Hewatt, W. G. prof. biol. Texas Christian. OM 24.
Honegger, Carol Temple. Br 214.
Hutchings, L. M. teach. biol. Weequahic High School (N. J.). (left).
Kilrick, A. C. asst. biochem. New York Med. Br 206.
Knowlton, F. P. prof. phys. Syracuse Med. Br 226.
Kopac, M. J. visiting asst. prof. biol. New York. OM 44.
Lavin, G. director, Spectroscopic Lab., Rockefeller Inst. Br 206.
Loewi, O. res. prof. pharmocol. New York Med. Lib.
Long, M. Jeanne res. asst. zool. New York. Br 232.
Machado, A. L. res. fel. Yale Med. Br 336.
Martin, W. E. assoc. prof. zool. DePauw. OM 27.
Mattox, N. T. asst. prof. zool. Miami. OM 29.
Merritt, Frances A. lab. asst. Lilly Res. Lab. Br 319.
Nachmansohn, D. Columbia.
Osterhout, W. J. V. mem. phys. Rockefeller Inst. Br 209.
Runyon, E. H. assoc. prof. bot. Agnes Scott. Br 315.
Sales, L. P. asst. prof. biol. City N. Y. Br 318.
Shapiro, H. instr. phys. Hahnemann Med. (Philadelphia).
Shanes, A. M. instr. phys. New York Dent.
Simpson, Jennie L. S. asst. prof. bot. Hunter.
Smith, D. E. res. asst. Ohio State. Br 111.
Springer, S. Marine Sudios. Br 108.
Stevens, Hazel A. lab. asst. Lilly Res. Lab. Br 319.
Stokey, Alma C. prof. zool. Mt. Holyoke. Br 121.
Stunkard, H. W. prof. biol. New York. Br 233.
Wilhelmi, R. W. instr. zool. Missouri. Br 325.
Woodward, Jr., A. A. asst. phys. Wesleyan. Br 209.

INVERTEBRATE ZOOLOGY

Staff

Instructors

Buck, J. B. asst. prof. zool. Rochester
Burkenroad, M. D. asst. curator, Bingham Oceanographic Foundation (Yale).
Hewatt, W. prof. biol. Texas Christian.
Martin, W. E. assoc. prof. zool. DePauw.
Mattox, N. T. asst. prof. zool. Miami.
Waterman, A. J. assoc. prof. biol. Williams. in charge.
Wilhelmi, R. W. instr. zool. Missouri.

Assistant

Merwin, Ruth grad. zool. Chicago.

Students

Benson, J. A. asst. biol. Wesleyan. K-5.
Brearley, Margery grad. zool. Mt. Holyoke. W-a.
Chroniak, W. Massachusetts State. Dr.
Cole, Elsie Louise grad. zool. Heidelberg (Ohio). K-2.
Cole, M. Ethel teach. biol. Pittsburgh Pub. School.
Collard, LaVerne Ellen grad. biol. Oberlin. K-8.
Cosby, Evelyn Linda lab. instr. bot. Richmond. K-2.
Cregar, Mary Wilson. W-b.
Daughaday, Eleanor Frances Vassar. W-e.
Dintiman, Sara Mae New Jersey (Women). W-h.
Donaldson, Sara Louise grad. asst. zool. Syracuse. D-302.
Doochin, H. D. grad. zool. Miami.
Fogg, N. W. American International. Dr-7.
Foster, J. J. grad. asst. biol. Amherst. Dr-2.
Franklin, Rev. R. G. prof. biol. St. Joseph Seminary (Yonkers).
Haas, Elizabeth Bennington.
Hufford, Virginia grad. asst. zool. Mt. Holyoke. K-8.
Hyde, Jane E. Radcliffe. W-b.
Johnson, V. T. (Cambridge, Mass.).
Keister, Margaret L. instr. zool. Wheaton.
Lesage, M. C. teach. biol. St. Francis Xavier High School (Massachusetts).
Lorentz, J. J. grad. biol. Fordham.
Manny, Ella T. Sarah Lawrence. W-d.
Newcomer, S. grad. asst. zool. Cornell. K-5.
O'Rourk, Ann Elizabeth grad. biol. Duke. K-3.
Peterson, H. L. asst. zool. Drew. K-6.
Philbrick, Madeline G. Russell Sage. D-309.
Rayner, Harriet A. Massachusetts State. W-d.
Saunders, J. W. grad. asst. zool. Hopkins. K-6.
Schmeisser, Elizabeth F. Sweet Briar. D-309.
Taft, Edith D. Wheaton. W-e.
Waterman, G. E. prof. biol. Assumption (Worcester). D-112b.
White, Marcia R. Cornell.
Wood, Marcia Russell Sage. W-g.

Among those working at the Marine Biological Laboratory who have left recently are Dr. S. M. Nabrit, Dr. C. Phillips, J. P. Trinkhaus, Dr. V. Hamburger, Dr. F. F. Shelden, Ruth C. Child, Dr. K. C. Fisher, Dr. N. B. Dreyer, and L. M. Hutchings.

EMBRYOLOGY CLASS NOTES

Suddenly, without warning, the sign on the front door of Old Main metamorphosed from "Embryology" to "Invertebrate Zoology". Spiral cleavage, trochophores, veligers, towing, the Eel Pond, and tunicates contributed their bit towards the finished product as Dr. Hamburger passing out slips of white paper said, "Well, you did pass after all."

"Oblique right! Oblique left! Double to the rear, march!" were the commands Dr. Watterson gave to *Crepidula* eggs as the untrained eye tried to follow the orders in spiral cleavage on Monday of last week. But not all *Crepidula* eggs are to remain at the Woods Hole Base as stained individuals are being transported to other camps.

The series from eggs to trochophores to veligers was continued at the end of the week with Dr. Hamburger giving his last lecture of the embryology course, 1942. In fifteen minutes he concisely summarized not only the development of annelids and molluscs, but also developmental theories in general. The one outside lecturer of the week was Dr. Bodenstein who outlined dramatically the difficulties he had encountered in determining the factors involved in insect eye development.

After supper on Friday, the class was plunged into the most respected of Woods Hole traditions, the "splash party", when a group of the fairer sex accepted a challenge to toss Trink into the drink. As a result of the struggle, not one but *four* people appeared at Dr. Harvey's lecture with dripping locks.

Saturday morning occurred the annual towing trip—the field trip for which experienced ex-invertebrates had waited patiently so they might catch a glimpse of old collecting grounds. Before the *Tern* and *Nereis* were in open waters, all of the embryologists were rapidly becoming as damp as the four who had been thoroughly infiltrated with sea water the night before. Drenched, but sporting, collectors returned after one and a half hours of gathering combined fresh and salt water (plus the microscopic billions that made Pratt become popular with us).

Sunday afternoon found the class in the mood for going places and doing things, so "they dood it." "Poppa" Shea and his flock went to town for dinner and a show and hitch-hiked home at midnight for a feed in the brick dorm living room. Some ambitious souls even went for a dip after that!

Weekend activities ceased as the class became sessile to study metamorphosing tunicates under Dr. Watterson and to listen to Dr. Grave's account of his many experiences with ascidians. It was not until Tuesday afternoon that disintegration of the class really set in. By four o'clock the laboratory was in confusion. Instruction sheets, drawings, and tads all became buried under time tables and microscope packings as all but a lucky few prepared to depart.

The plans of the various class members are varied. Margie Beardsley expects to relax at home on Sunset Farm in West Hartford for the rest of the summer and in the fall will invade the halls of Brown University as a Zo assistant. Mary Boss in transferring her interest from fauna to flora as she will be counting molds in tomato juice for the Gibbs and Company canning factory in Baltimore. In September she will be a senior at Goucher. Buggs, when interviewed, exclaimed first, "I'll be back *here* next summer!" But before that he has an enviable program. The rest of this summer he will be collecting jellyfish in the Gulf of Mexico for biochemical analysis. Autumn will find him at the University of Chicago doing research in experimental embryology under Dr. DuShane.

"Carpie" will be at home until September loafing when she isn't struggling with lectures for the general zoology course and the anatomy and physiology course which she will be teaching at Westbrook Junior College in Portland next year. Gus and Ross Churchill will enjoy life in Washington with their parents before returning to Urbana where Gus claims he is going to study for "those exams." In the fall he will be teaching "whatever needs to be taught" at the University of Illinois. "Edie" Cole is one of the fortunate ones remaining in Woods Hole. She will be working on the regeneration inhibitor in *Pennaria* under Dr. Barth. Next year she will be a senior and an undergraduate assistant in biology at Penn. College for Women.

Sam Dodd is one of many whose future is unpredictable. Uncle Sam willing, he will be assisting at Johns Hopkins next year (and visiting Vassar occasionally?). "Barbie" Dunn declares that she is going home to sleep (too many midnight swims!) and also to think about that thesis she will be writing at Wellesley next year. "Cathy" Elias is keeping us guessing about her future, except that she'll be at home in Mt. Kisco.

Sister Francis is another who is staying in Woods Hole, invading the library and doing private research for three weeks. Early in September she will return to Washington to start work on her doctorate at Catholic University.

Jim Foster, the inevitable "Vera," will no doubt lounge through the Invert Course and return to Amherst in the fall to be, according to

rumors, the only male assistant in the biology dept.

Carl Gajdusek, the class authority on plant hormones, will be a lab assistant at the Boyce-Thompson Institute of Plant Research during part of the summer and will return to Rochester as a senior in September.

Jimmy Littrell is going to move from sodas in a local drug store to *Crepidula* in O. M. 39 daily for the coming weeks. After sunbaked Chambana has cooled, Jimmy will start assisting in histology and embryology at University of Illinois. For two weeks in August Dottie Newfang is going to be learning tissue culture technique with Frances Humm at Yale in preparation for her next year's work under Witschi at Iowa St. U. Before Nick Nickerson goes back to teaching anatomy at Johns Hopkins, he will have participated in the solemn religious ceremony indulged in only by embryologists Churchill and Memhard.

Maddie Philbrick and Marcia Wood are going to keep Vera from handing in late drawings during the Inverts course as they are also going to continue their quest for knowledge of marine dwellers. After next June, Maddie and Woodie will have B. A. 1943 Russell Sage College after their names.

Joan Poindexter has profited by swims at Stoney by keeping in training to carry out her job for the rest of the summer as head of swimming at the Scout Camp in Westfield, Mass. In September a really browned lass will return to be a member of Smith class of '43. The army has almost caught up with Johnny Prodell, but there's still a chance that he may beat the armed forces back to Drew University and get a chance at seeing how it feels to be in the top class. Randy Reyer is another one looking forward to a vacation before he goes back to Yale to assist in zoology.

Meg Seitner has become successor to Gege in the "Mess." Between polishing silver and sunning, she will pickle Arbacia eggs for the Supply Department. In September Meg will be a Holyokel assisting the Zo Department of the College in South Hadley. Nita Senyard is another stayer on as she is going to help Dr. Watterson try to find out what the nervous system of *Botryllus* is like by using a new silver technique described by M. L. Silver. By September Nita will be back at Holyoke assisting in histology. Sammy Shea is moving south along the coast to Duke University's Marine Lab where he is going to take ecology. In the fall Sammy will be back in Buffalo to finish up his undergraduate education at Canisius.

Before the embryologists are scattered from Urbana to Skowhegan, they wish to express their appreciation to Dr. Hamburger, staff, assistants, collectors, and janitors for making the embryology course the best thing yet. —*E. C. and J. S.*

INVERTEBRATE CLASS NOTES

The inroads made in the student bodies and faculties of educational institutions throughout the nation by the war situation have also had their effect at the M. B. L. Numerous professors and students of former years are missing from the ranks, and the enrollment in the Invertebrate Class alone has been cut almost in half. We hope that it will not be long before the M. B. L.'s original status will be restored.

There are some thirty-odd students in this year's Invertebrate Class, representing some twenty-five different institutions. Most of the Class arrived the Thursday afternoon before classes began and got themselves arranged and settled before the meeting Thursday evening.

The main speaker at the first meeting was Dr. Taylor, who lectured on "Invertebrate vs. Vertebrate Structure," and drew an interesting series of comparisons between these two great phyla. Dr. Taylor laid special emphasis on the fact that it is amazing that the animal kingdom, varied conglomeration of specimens that it may be, has not varied more, in view of the tremendous diversity of environment to which its members have been, and are being subjected to. He attributes this broad similarity which exists among animals to Nature's common denominator of persistence.

The Class realized as soon as Friday night had come, that it had a tremendous amount of work to encompass in the five short weeks allotted to it for its completion. After spending two days in brief survey of the Protozoa, and one-half day on the Porifera, we left for a field trip to Stony Beach. About seventy-five to eighty-five different forms were collected, brought back to the lab and classified. A somewhat different procedure in making the field trip reports has been suggested by the staff this year. The emphasis on ecology is being stressed more than before, and rather detailed reports concerning general habitats, their nature and the most common animals which would be found in those particular habitats have been made, in an attempt at further correlation between the organism and its environment. The staff will keep reports of this nature on all the field trips and hopes to continue this process from year to year. On Wednesday a second field trip to Lackey's Bay was taken and the same procedure followed, with the appearance of some different forms than had been found at Stony Beach, but in about the same number.

The last three days have been spent on the Coelenterates, with lectures by Dr. Burkenroad which were marvellously well organized and delivered. He covered a tremendous amount of territory comprehensively, and this Class was so fortunate as to have available for laboratory study Scyphozoan forms, the Cyanea, which were about an inch in diameter and more than satisfactory for laboratory study. Such specimens have not been available for the past five years, according to Dr. Mattox.

Those of us who are new here wish to express our thanks to Dr. Waterman for his kind attention and advice during the first few days, and we feel that he has done an effective job of introducing us to the M. B. L. He delivered the first lectures on the Protozoa and will deliver the last on the Protochordates.

Of course there have been the usual run of amusing incidents, such as someone looking for the old "Mess," which is now safely ensconced behind the Navy fence. Then there was some brilliant "stude" who cut class the first week-end for some Boston business—two profs waiting dejectedly on the baseball diamond for a game that never materialized, at the suggestion of two beautiful Inverts who were supposed to have arranged the game. Ruth, the lab assistant, running around with an extra window shade and no place to put it. Complications? We are blessed with a portable radio that only works when pointing at the north pole—picture your male correspondent standing forlornly by the drawbridge watching the loaded excursion boat leave for the second field trip sans same correspondent. Someone lost the *Ark* last time; it floated away when the tide came in. A kind-hearted octopus waddled into lab that evening, deposited the lost *Ark* on the table and departed without words.

—Bill Fogg and Evelyn Cosby

BOTANY CLASS NOTES

Since the last edition, the class has entered upon the final and most interesting phase of its work at Woods Hole—the brown and red algae. We have already gained great familiarity with the nearby fresh-water flora and are now fast becoming adept at recognizing most species with which we come in contact at Stony Beach and find floating in the harbor. Indeed many a harmless swimming or boating expedition has suddenly become transformed into an impromptu collecting trip by the enthusiasm of the members.

These marine species contrast sharply with the fresh-water organisms both in respect to size and to complexity, although parallel evolutionary tendencies may be traced. Although the brown are very massive plants, they are surpassed in complexity by the reds. The red algae also show an amazing adaptation to the light penetrating to their extremely deep habitat.

Upon two occasions, Dr. Taylor was kind enough to show his personal movies to the class and assembled guests. The first group showed both methods of collection, and algae growing under natural conditions near Woods Hole. These films showed ecological zonation very well. We enjoyed seeing familiar scenes and activities carried out in much the same manner by previous classes. The second showing brought to us views of algal research in foreign waters taken by Dr. Taylor in 1939 on the Hancock Expedition to Central and South America. The class was able to view many tropical genera which would otherwise have been only textbook illustrations. Dr. Taylor is to be congratulated on his superb photography.

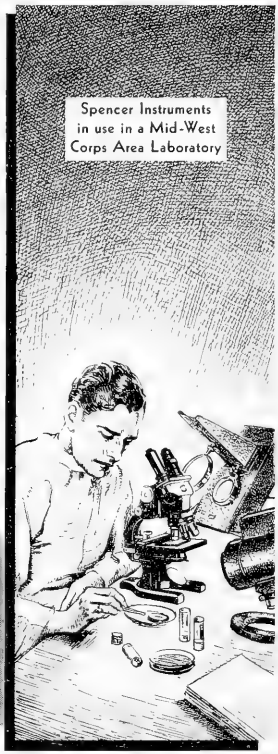
After a day's delay due to inclement weather, the class at last journeyed to Gay Head where, in the pounding surf, we managed to grapple for otherwise unobtainable specimens, including a Portuguese Man-of-War. The most impressive specimens were large kelps tossed upon the beach by the high wind, some in perfect condition and as much as five feet in length. Great difficulties were encountered in effecting a landing and embarkation amid the tempestuous waters, but all finally returned safely to the *Nereis* where both specimens and lunch were soon carefully stowed away. Homeward bound, the dredge was lowered in the shallows off Nonamesset Island, but nothing of botanical significance was forthcoming.

This botany report would be incomplete without a slight reference to the class excursion to Nantucket on the 19th, where, in spite of missed boats, everyone enjoyed bicycling around the island and swimming in the surf.

The class is now looking forward to its final trip which will be Black Rock in New Bedford Harbor where fruitful opportunity for study has been reported. *—J. B. and E. R.*

Dr. Edwin J. Cohn, professor of biological chemistry and head of the department of Physical Chemistry at Harvard Medical School, has been awarded the Alvarenga Prize by the College of Physicians of Philadelphia in recognition of his research work on blood proteins. In the past Dr. Cohn has worked several summers at the Laboratory.

Professor Ross G. Harrison, trustee emeritus of the Marine Biological Laboratory, is working in Washington about two-thirds of the time where he serves as chairman of the Division of Biology and Medicine of the National Research Council. The rest of the time he is at Yale.



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Vol. XVII, No. 4 SATURDAY, AUGUST 15, 1942 Annual Subscription, $1.00 Single Copies, 30 Cents.

FISHERIES RESEARCH AT THE PACIFIC BIOLOGICAL STATION

DR. R. E. FOERSTER

Director, Pacific Biological Station, British Columbia

During the last few years there has been a very definite and significant change in the character of the research carried on at the Pacific Biological Station at Nanaimo, British Columbia. From 1908, when the Station was first established, until 1924 the Director was the sole permanently-employed scientist, and during the summer months investigators, both senior and junior, came from the various Universities of Canada—also a few from United States institutions — to conduct biological, biochemical, or physiological studies in which they were particularly interested. After 1924 more and more emphasis came to be placed on economic fisheries problems and in consequence a permanent staff of research workers gradually developed. For a few years voluntary workers came to the Station and were given all facilities, but with the well-known depression of the '30's, not only were scientists less

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M. B. L. Calendar

TUESDAY, August 18, 8:00 P. M.

Seminar: Dr. Dorothy Wrinch: "The structure of biologically active membranes."

Dr. Douglas Marsland: "The contractile mechanism in unicellular melanophores."

Dr. E. R. Runyon: "The aggregation of cells of Dictyostelium."

FRIDAY, August 21, 8:00 P. M.

Lecture: Dr. Robert F. Griggs: "Timberlines as indices of climatic change."

FRIDAY, August 28, 8:00 P. M.

Lecture: Dr. C. W. Metz: "Evolutionary Chromosome Changes in Sciara as Shown by the Giant Salivary Gland Chromosomes."

ON THE MECHANISM OF TRANSMISSION OF NERVE IMPULSES

DR. DAVID NACHMANSOHN

Research Associate in Neurology, College of Physicians and Surgeons, Columbia University

It is just 150 years since 1792 when Galvani published his book "De viribus electricitatis in motu musculari." From his epoch-making discoveries and the subsequent controversy with Volta emerged two fundamental facts of nerve and muscle physiology: both structures are stimulated by electrical current and, if active, generate electricity.

The study of the electrical changes during nerve activity made rapid progress owing to the work of outstanding physiologists of the last century like Helmholz, Pflueger, Du Bois-Reymond and others. Each new development of electric recording instruments led to new and great achievements in electrophysiology as we have seen since the introduction of the oscillograph by Gasser and Erlanger. Our knowledge of the electrical phenomena during nerve activity has reached a high level.

The function of nerve cells to carry messages from one distant point of the organism to another

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BOTANY CLASS AND STAFF

First Row: Mary Louise Booth, Jane Behnke, Margaret Hitchcock, Eunice Kingsley, Margaret Young. **Second Row:** H. Arrowsmith, E. Richardson, J. J. Paull, Jr. **Third Row:** Dr. H. T. Croasdale, Dr. W. R. Taylor.

offers two distinct problems: (1) How an impulse is transmitted along the nerve fiber, and (2) how, at the nerve ending, this impulse is transmitted either to a second nerve cell or to the effector organ. Electrophysiologists, until recently, studied mainly the excitable properties of the nerve fiber. At the beginning of this century the conception appeared that a chemical substance might intervene in transmission from efferent nerve to effector cell. It was Elliot, in 1904, who first suggested that sympathetic endings might liberate a substance like adrenaline. This substance would then act upon the cell. Elliot's suggestion was based on the very close similarity between the actions of adrenaline and sympathetic nerve stimulation. But it was the classical work of Otto Loewi and his collaborators during the years 1921-26 which brought experimental evidence for the intervention of a chemical substance in the transmission of nerve action in the heart. Otto Loewi and his associates established the following fundamental facts: (1) When the heart vagus is stimulated, a substance is liberated which was later identified with acetylcholine (ACh). (2) This substance reproduces the effect of vagus stimulation. (3) The heart tissue contains an enzyme, which inactivates acetylcholine. (4) This enzyme is specifically inhibited by eserine, which if injected into the heart, prolongates and intensifies the effects of vagus stimulation. These discoveries led to a great number of investigations and evidence was accumulated supporting the view that all sympathetic and parasympathetic nerves act on the effector organ by virtue of chemical mediation. It is generally believed that ACh is the transmitter substance at parasympathetic nerve endings, whereas adrenaline or a related substance, sympathin, has the same function at the endings of sympathetic nerves.

A new period started in 1933. Kibjakow, and Dale and his associates suggested that ACh might be the transmitter across ganglionic synapses, that is, from neuron to neuron. Later the same theory was proposed for the transmission of impulses from motor nerves to striated muscle. These suggestions were based essentially on the same kind of experiments as in the case of the peripheral autonomic system: liberation of ACh after stimulation of preganglionic fibers or motor nerves, stimulation of the ganglion and muscles by injection of small amounts of ACh and potentiation of the effects of nerve stimulation by eserinization.

There remained a great number of difficulties and contradictions which have been reviewed and summarized by Eccles. The facts would be sufficient to admit the cholinergic nature of a parasympathetic nerve, but for the transmission of the excitatory process across ganglionic synapses or at neuronmuscular junctions a new additional factor is of primary importance—one which dominates all the aspects characteristic of this transmission. This is the time factor. This factor could be neglected for the action of peripheral autonomic nerves; they innervate slowly reacting cells. Neurons and striated muscle fibers are very

quickly-reacting cells. The transmission of nerve impulses across ganglionic synapses or at neuromuscular junctions occurs within a few milliseconds or within a fraction of a millisecond. Chemical reactions connected with this transmission must therefore occur with the same rapidity. In 1933, before there was any evidence for a role of acetylcholine at neuromuscular junctions, Adrian considered the possibility of a transmission of nerve impulses from motor nerve endings to striated muscle by a mechanism analogous to that shown by Otto Loewi for the vagal action on the heart. He insisted especially on the importance of this time factor. Dale and his associates emphasized the necessity of a quick removal of the liberated ACh. They admitted that this was one of the chief difficulties encountered by their theory. This time factor was also the main argument of Eccles in his critical review against the theory of a transmitter function of ACh in transmitter processes of short duration.

According to all opinions whether or not in favor of the transmitter function of ACh across synapses and neuromuscular junctions it appeared essential to know whether the rate of ACh metabolism is as high as required by such a theory.

The problem has been approached by investigations on the rate at which ACh can be removed at motor end plates and synapses. The only mechanism, which could be conceived, in terms of known agents, to destroy ACh with the required rapidity, was a sufficiently high concentration of the enzyme choline esterase (Ch. E.) at the site of action. This enzyme inactivates ACh by splitting it in acetic acid and the inactive base choline. Its existence was first shown by Loewi and Navratil in 1926, and evidence for its specificity was shown by Stedmans and more recently by Glick.

The enzyme is extremely stable. Its activity, at low temperature, remains unchanged for many weeks and months. ACh, on the other hand, is an extremely unstable ester. If it is connected with transmission of nerve impulses to quickly reacting cells, it will persist only milliseconds. No chemical methods are available for estimating the rate of such a rapid metabolism except by studying the activity of the enzyme specific for the substrate. For the amount of ester itself, which will be determined, will not give any indication about the amount present at the moment of activity but only at the moment when most of it has been hydrolized. The concentration of a specific enzyme in a cell can be used as indicator of the rate of metabolism of its substrate. One of the essential results of the work with isotopes, as Schoenheimer and Rittenberg pointed out in their review, is the indication that no enzyme lies dormant during life, as some physiologists still believe, but is continuously active. Although the rate of the activity is most probably not optimal and excess of enzyme always available, we have the right to assume that there does exist a definite relation between the concentration of an enzyme and the rate of metabolism of its substrate.

Studies on the concentration and distribution of the enzyme Ch.E. have revealed that at motor end plates and ganglionic synapses as well as at synapses of the central nervous system considerable amounts of ACh can be split in milliseconds. These amounts, if released at those foci, would be high enough for a stimulating action.

Choline esterase in striated muscle.

Striated muscle have a surprisingly low concentration of Ch.E. If the enzyme were evenly distributed, it would take about 100 seconds in frogs and 300 seconds in mammalian muscle to split at the nerve endings an amount of ACh which would have a stimulating effect. If ACh acts as transmitter it should be removed during the refractory period from the site of its action. The refractory period is about 5 msec. in frogs and 2 msec. in mammalian muscle. The time of hydrolysis by the muscle fiber is therefore about 50,000 times longer than the refractory period. But if, in frog's sartorius, the concentration of Ch.E. in the nerveless pelvic end is compared with that in parts containing nerve fibers and motor end plates, the esterasic power is several hundred per cent higher in these latter parts than in the pelvic end. From the figures found for the sciatic nerve it can be calculated that the nerve fibers can not increase the esterasic power of the muscle by more than a few per cent. The increase of several hundred per cent can therefore be attributed almost wholly to a high concentration of the enzyme at the motor end plates. This indicates, since the end plates occupy not more than 1/1000 of the whole muscle volume and most probably much less, that the concentration of Ch.E. at the motor end plates is many thousand times as high as in the muscle fiber. The absolute amount of ACh, which can be hydrolysed at the nerve endings can be estimated since we know the number of end plates per muscle. About 2×10^{-6} μg of acetylcholine can be split at a single nerve ending of a frog's sar-

"The Collecting Net" was entered as second-class matter July 11, 1935, at the Post Office at Woods Hole, Mass., under the Act of March 3, 1879, and was re-entered on July 23, 1938. It is devoted to the scientific work at marine biological laboratories. It is published bi-weekly between July 1 and September 1 from Woods Hole, and is printed at The Darwin Press, New Bedford, Mass. Its editorial offices are situated in Woods Hole, Mass. Single copies, 30c; subscription, $1.00.

torius during the refractory period. This amount corresponds to 8×10^9 molecules of ACh; if released it would certainly have a stimulating effect.

Evidence for a high concentration at motor end plates can also be offered with mammalian muscle: in the interior section of the gastrocnemius of guinea-pigs all motor end plates are located at one level only. The concentration of Ch.E. in this part is 6-8 times as high as that in a part free from nerve endings. After sectioning of the motor nerve when the degenerated fibers have disappeared the enzyme concentration in the part containing the motor end plates remains practically unchanged.

Choline esterase in sympathetic ganglion and central nervous system.

As for the neuromuscular junctions it could be shown for the synapses of the sympathetic ganglion, that Ch.E. is present in a concentration sufficiently high to satisfy the requirements of the theory that ACh is involved in the transmission from pre- to postganglionic fibers. $2\text{-}3 \times 10^{11}$ molecules of ACh can be liberated by a maximal shock in the superior cervical ganglion of cats. The concentration of Ch.E. is very high in the preganglionic fibers but is still about 10 times higher in the ganglion in which $3\text{-}6 \times 10^{12}$ molecules ACh can be split during one millisecond, i.e., the approximate time of the passing of an impulse. Only the enzyme present at synapses outside the fibers can account for the removal of ACh liberated. If the preganglionic fibers are cut and have disappeared, the concentration of the enzyme has decreased by 60 per cent. The remaining amount of enzyme has to be considered as the amount outside the fibers. Ten per cent of this amount would be sufficient to split in one millisecond the amount of ACh which is liberated by a maximal shock.

Ever since evidence was presented that ACh might be the transmitter of nerve impulses from motor nerves to striated muscle or from neuron to neuron, many prominent neurophysiologists envisaged the possibility of the same mechanism at the central synapses, and Dale recalled in his Harvey lecture, in 1937, that Sherrington looks upon the transmission of excitation from a motor nerve ending to a voluntary muscle as probably furnishing a pattern of what happens at a central synapse. No experimental data were available at that time. Investigation on the enzyme mechanism in the central nervous system have shown that the same enzyme mechanism exists at central synapses as that found at motor end plates and at ganglionic synapses. In the gray matter which contains the cell bodies and synapses, the concentration of Ch.E. is always high whereas it is comparatively low in the white matter. Great variations are found in the different parts of the brain. In the ox brain, for instance the values of the esterasic quotient, QCh.E. (= mg ACh split by 100 mg fresh tissue in 60 min), are 2-3 in the cortex, 15-20 in the retina, about 40 in the nucleus caudatus and 69 in the nucleus lentiformis. The values vary considerably from one species to the other. A most remarkable fact about these figures is the great constancy of the values for the same part and same species in striking contrast to the variations between the different parts and the different species; but the essential point is again that at central synapses amounts of ACh can be split in one millisecond, which are of the same order of magnitude as at motor end plates and at ganglionic synapses. The very existence of such a specific enzymatic system at all these foci strongly supports the view that the substrate there has the same function and is in agreement with the view of Sherrington: that the mechanism of transmission is essentially similar at all synapses.

Choline esterase during embryonic development.

If ACh has a role intrinsically connected with transmission of nerve impulses at neuromuscular junctions and at synapses, a high concentration of Ch.E. should be present at a very early stage of development, actually at the time when the first muscular movements occur and the different centers of the central nervous system begin to function. Such a relationship between enzyme concentration and function during embryonic development could be demonstrated in many different ways. Two examples may be given as illustration. In the muscle of chick embryos the concentration of enzyme increases rapidly to high values during incubation. The QCh.E. of breast muscle, e.g., is about 10 at hatching. After hatching the values go down, the QCh.E. of fowl muscle being only 0.4-0.5. Motor end plates are developed at an early stage of muscular growth. Muscle fibers are extremely small during the last few days of incubation and at hatching. Per unit of tissue weight there is, therefore, a large number of end plates. Later, when the fibers grow, the number of end plates per unit of weight decreases. The high concentration of the enzyme in muscle at a very early stage of development offers therefore evidence for a high concentration of the enzyme at motor end plates at that period, for if the number of end plates per unit of weight falls, the concentration of enzyme decreases correspondingly.

Experiments carried out on sheep foetuses may be quoted as another example. The different centers of the central nervous system do not develop at an equal rate. During recent years this problem has been investigated by Barcroft and Barron in connection with the movements and reflexes of

sheep foetuses. Their observations offer evidence for the early development of spinal reflexes and of the relatively delayed period at which the brain enters into action. The time when the different centers begin to function, according to the observations of Barcroft and Barron, coincides with the appearance of a high concentration of choline esterase: this concentration is high in the spinal cord at a very early age of the sheep foetus, but low at that time in the different brain centers; there it rises to high values only during the last weeks before birth.

The fact that ACh metabolism has the same rate at the central synapses as in ganglia or neuromuscular junctions is a strong argument for the assumption that the physiological function of the described enzyme system is the same at all three foci. Such a concept is supported by other observations, some of which may be mentioned briefly. Bonnet and Bremer found a stimulating action of ACh on the activity of cortex and spinal cord. The dose applied was significantly small—0.1 μg. Chang and co-workers have demonstrated that ACh is liberated in central synapses. The action of ACh, eserine and related substances on the central nervous system has been tested by several investigators. The interpretor, however, has to keep in mind the complex nature of pharmacological actions, which is only relevant if supported by other kind of evidence. Several other observations which cannot be discussed here, point in the same direction.

The facts described so far support the view that ACh is involved in the transmission of nerve impulses across central synapses as well as across neuromuscular junctions and ganglionic synapses. This does, however, not imply that ACh is the synaptic transmitter of nerve impulses as originally conceived. For many years there was a controversy between the so called "electrical" and "chemical" theory of transmission. But actually the fundamental difference between the two opposite views was not the question whether transmission is electrical or chemical; it was the question whether conduction along fiber and across synapses differ in principle. The work of Eccles and Sherrington and that of Lorente de Nó indicates, that the excitable properties of the central neurons are similar to the excitable properties of pheripheral nerves, i.e., the axons. The problem has been scrutinized by Erlanger in the symposium on the synapse in 1939. Analyzing some of the pecularities attributed to the synapse, namely latency, one way transmission, repetition, temporal summation or facilitation and transmission of the action potential across a non-conducting gap, he points out that all these phenomena can also be demonstrated on fibers. Gasser arrives at a similar conclusion. The facts based on the electrical signs of nerve activity make it thus unnecessary to assume, especially in view of similar time relations, that any condition exists which differs essentially in basic nature from that found in the peripheral axons.

How are these facts compatible with the observations on the role of ACh? Recent investigations suggest that the original conception has to be modified and that ACh metabolism is closely connected with the electrical changes occuring everywhere at the neuronal surface. It is only qantitatively more important at the synapse, where the neuronal surface increases due to the extensive endarborisation. The new concept is based on two lines of investigations.

(1) *Relationship between E.M.F. and choline esterase activity in electric organs.*

It could be shown that a relationship exists between the activity of Ch.E. and the E.M.F. of the action potential. These experiments were carried out on the electric organs of fishes. Twenty years before Galvani's discoveries in 1772, Walsh demonstrated before the Royal Society in London that the shock of certain fishes known since ancient days was an electrical discharge. It was the first evidence for animal electricity. When Galvani's observations made it clear that electricity is a common property of nerves, physiologists became interested in these organs. Galvani himself worked in the last year of his life on electric organs, and many outstanding physiologists of the last century, especially Du Bois-Reymond, did extensive investigations on these fishes.

There are three species known with powerful electric organs, and several others with weak electric organs. The most powerful species is the *Electrophorus electricus* (Linnaeus), the so-called electric eel, which occurs in the Amazon in Brazil. The maximal discharge of some individuals of this species is more than 800 volts. Another powerful species is the Malopterurus, which is found in the Nile in Egypt. The maximal discharge can be 400 volts and more. A more common species occuring in different parts of the world is the Torpedo. A particularly large species occurs in the water around Cape Cod: the *Gymnotorpedo occidentalis*, first described by Storer in 1848. Several specimens were examined in the Marine Biological Laboratory. The discharge of Torpedo is generally only 30-70 volts, but in the large Gymnotorpedo, as has been measured here by R. W. Amberson and D. T. Edwards, it is 150-200 volts and even more.

The electric organs are considered as modified muscle end plates, phylogenetically evolved from striated muscles, as was shown by Babuchin in 1870. The muscular part has disappeared in the

strong electric organs, which are formed by columns. These columns are subdivided in compartments and in each compartment is an electric plate. They resemble a voltaic pile; Volta discovered the analogy and called his pile an "artificial electric organ." Only one side of the electric plate is innervated. This side becomes negative during the discharge, whereas the opposite side becomes positive.

The electricity of the discharge does not differ in principle from that of ordinary nerves. It is only the arrangement in series by which these organs are distinguished and by which the great E.M.F. is obtained. This was early recognized by the physiologists of the last century. As has been recently outlined by A. V. Hill, the discharge of these fishes is fundamentally identical with the action potential of ordinary nerves. For an understanding of the mechanism of the discharge, the time factor is again of great importance. In a single second 100-200 discharges can be obtained in the strong electric organs. Latency, duration, refractory period, etc. are the same as in the nerve action potential. If a polarizing or depolarizing substance is responsible for the discharge, appearance and disappearance of the substance has to occur within milliseconds. In other words, the assumption that ACh might be the substance implied the existence of a most powerful esterasic system.

High concentrations of Ch.E. are found in the strong electric organs of Torpedo and *Electrophorus electricus*. These organs can split in 60 min. an amount of ACh equivalent to 1-3 times their own weight or even more. As in the larger specimens the organs have a weight of many kilograms (up to ten kg in the *Gymnotorpedo occidentalis*) the amount of ACh, which can be split by the enzyme present in these organs may be many kilograms in 60 min., that is, several milligrams in one millisecond. This high rate of metabolism makes possible the assumption that ACh is closely connected with the discharge.

Electric organs are highly specialized in their function. The existence of such a high enzyme concentration appears particularly significant in view of the high water and low protein content of these organs: 92 per cent of the organ is water, and only slightly more than 2 per cent, proteins.

In the weak electric organ of Ray the enzyme concentration is relatively low. If, in the three species number of plates per cm and E.M.F. per cm are compared with the concentration of Ch.E., a relationship becomes obvious.

The relationship between E.M.F. of the discharge and the concentration of Ch.E. could be established in more precise form in recent experiments with Drs. Cox, Coates and Machado. In the electric organs of *Electrophorus electricus* the number of plates per cm, the E.M.F. per cm and the concentration of Ch.E. decrease from the head to the caudal end of the organ in an S-shaped form. The electrical values—voltage, amperage and resistance—have been recorded and on the same animals and at the same sections, chemical determinations and histological preparations were made. The results show a close parallelism between V per cm and concentration of Ch.E.

The E.M.F. varies greatly from one species to the other. It is relatively higher in the small fishes, but even in absolute amounts a parallelism is obtained between electrical potential and enzyme activity. The histological preparations show that the aspect of the voltaic pile changes at different sections. The anatomical picture corresponds to the electrical and chemical data.

The parallelism between E.M.F. and Ch.E. concentration appears to be specific. In sharp contrast to the variations of the esterasic quotient the rate of respiration is equal throughout the organ. Other enzymes and substances examined so far did not show any parallelism with the electric potential.

The assumption that the discharge is connected with ACh metabolism is supported by observations made with Fessard and Feldberg on the electric organ of Torpedo. ACh appears during stimulation in the perfusion fluid, provided the Ch.E. has been inactivated by eserine. Injection of small amounts of ACh into the organ produces a discharge. After eserinization the electrical potential is much higher. Since eserine alone has no effect, these experiments demonstrate the electrogenetic power of ACh.

(2) *Localization of choline esterase inside the nerve cell.*

The second line of observations leading to a modification of the original theories, is the localization of the enzyme inside the nerve cell. The concentration of choline esterase is high in all nerve fibers, but rises still more at synaptic regions. This is particularly obvious in non-myelinated fibers. In the abdominal chain of lobsters the QCh.E. values are as high as 5-15 and rise at the points where the synapses are located to values of 18-30. In the sympathetic chain of mammals the differences between trunk and synaptic regions are similar. Between myelinated fibers and gray matter the differences are somewhat greater, but in principle there is always only a quantitative difference. Furthermore, Lorente de Nó has shown that acetylcholine is released by ganglion cells after impulses have passed in which no synaptic transmission is involved and in peripheral nerves. This has been confirmed by Lissak. These facts indicate that ACh metabolism is

not limited to nerve endings. The experiments on the superior cervical ganglion on cats suggested that Ch.E. might be localized at or near the neuronal surface. Direct evidence for this view has been offered, in collaboration with Drs. Boell and Steinbach, with experiments on the giant fiber of squids. Ch.E. is localized practically completely in the sheath. In the axoplasm the enzyme activity is negligible.

It is important to know whether this distribution of Ch.E. is specific. Studies on the distribution of other essential enzymatic systems have been carried out in collaboration with Dr. Steinbach. It has been found that succinic dehydrogenase, widely considered as an important link in respiration, is mainly localized in the axoplasm (about 90 per cent of the total enzyme). The succinic oxidizing system has a similar distribution. If one accepts these links as indication for the total respiration, it would mean that the bulk of the respiration occurs in the axoplasm. This would be in agreement with the fact that the energy used for activity (heat production and extra oxygen uptake) is small.

Another catalyst studied was vitamin B_1 as cocarboxylase (diphosphothiamin) which is probably necessary for the synthesis of ACh, since it can be assumed that acetic acid comes from pyruvic acid. This reaction requires Vitamin B_1. Diphosphothiamin is concentrated in the sheath many times as much as in the axoplasm. Since it is an important coenzyme for many reactions, it could not be expected to be present only in the sheath; but the higher concentration in the sheath appears significant and may be an important factor in the sensitiveness of nervous tissue to Vitamin B_1 deficiency. For if the rate of ACh synthesis slows down, conduction of nerve impulses should be disturbed.

Since bioelectrical phenomena occur at the surface, the peculiar localization of Ch.E. appears particularly pertinent in connection with the relationship between electric potential and enzyme activity and the considerable amounts of ACh which can be metabolized in milliseconds. Thus the conclusion appears justified, that ACh metabolism is not limited to nerve endings, but is intrinsically connected with the electrical changes during nerve activity at the neuronal surface. As outlined above, the electrical signs of nerve activity are not compatible with the assumption of a chemical reaction specifically limited to the synapse. The new concept removes the chief difficulty for conciliating electrical and chemical theory of transmission of nerve impulses, for it makes unnecessary to assume a basic difference of the role of ACh for conduction along fibers and across synapses.

The relationship between E.M.F. and ACh metabolism does not imply that ACh generates the E.M.F. directly by action on the surface. Voltage is = E—IR. Beutner and Barns have described a model where ACh has a stronger E.M.F. than any other substance tried. ACh may act also on the resistance. Cole and Curtis have shown that the action potential is associated with a transient change in resistance. Both resistance and E.M.F. are closely associated properties of the membrane. The process of conduction is pictured as follows: the stimulus causes the quickly reversible breakdown of resistance. The resting potential disappears or is even reversed. Thus an electric current is generated, which stimulates the region just ahead. There the same process occurs and the impulse spreads along the fiber. Lillie's model shows that chemical wave transmission is possible. A polarizing or depolarizing substance which appears and disappears within a millisec. could well account for the transient changes occurring at the surface. Such an idea would be well compatible with the concept of propagated impulses as developed by Keith, Lucas and Adrian.

(This article is based upon a lecture delivered at the Marine Biological Laboratory on July 31.)

FISHERIES RESEARCH AT THE PACIFIC BIOLOGICAL STATION

(Continued from page 61)

able to take advantage of the Station's summer research facilities, but the financial help which the Station had been able to extend toward such work was also reduced. In consequence, the Station became essentially a fisheries research station in which life-history and statistical studies of the more important economic fishes were conducted by members of a permanent staff and individual research was restricted to a limited number of volunteer workers. The staff now consists of seven scientists and two technicians, as well as five clerical and non-scientific workers.

At the present time the work of the Station embraces chiefly life-history studies of the Pacific salmon, herring, pilchards, ling cod, clams and oysters, and statistical investigations of the commercial fisheries thereon, with a view (1) to obtaining further biological information upon which to base adequate regulatory measures and (2) to evaluating the condition of the fishery and its evident trend. Certain incidental investigations are undertaken from time to time as facilities or opportunities permit, such as the food of the albacore, the incidence of teredo infestation, the migratory habits of the dog-fish.

Field work in oceanography has been considerably reduced. A routine study of the salinity, density and temperature conditions prevailing in the coastal waters is being continued. At ten lighthouses along the coast and in the strait of Georgia, daily water samples are collected and water temperatures recorded. These are sent in to the Station, the chlorinities determined and the data filed for subsequent use. A hydrographical study of a long inlet (Alberni) on the west coast of Vancouver Island is being made with reference to the proposed establishment of a pulp mill at the head. This will be followed, it is anticipated, by a study of the present biological conditions in the inlet so that, should the proposed mill be established, any appreciable change in the picture can be brought to light by a subsequent examination.

A brief account of the individual fisheries investigations follows:

Pacific Salmon. Considerable attention has been paid to a study of the efficiency of natural propagation in a typical pink salmon (*Oncorhynchus gorbuscha*) stream. McClinton creek in Masset Inlet, Queen Charlotte Islands, was selected and since 1930, regular counts of ingoing spawning fish and outgoing fry have been made, under the direction of Dr. A. L. Pritchard. Computed on the basis of numbers of fry surviving to proceed seaward from a known egg deposition, the lowest percentage was 6.9, in the year of a relatively large run (52,000 fish) and the highest, 24.0 when a small run (10,500) occurred. An inverse correlation is indicated. Some data relating to the causes of mortality between spawning and fry migration have been obtained.

During 1942 a further study is being made of the migratory routes of the pink salmon on their return from the sea to their spawning stream. The fish were "marked" by removal of the pelvic fins at the time of seaward migration and a close lookout is being kept for the return of marked adults throughout the various fishing areas. At the same time data will be obtained as to the extent of return to the spawning stream and the degree of wandering to other areas of the coast.

Similar work is also being undertaken in connection with the spring or chinook salmon (*O. tschawytscha*), coho or silver salmon (*O. kisutch*) and chum salmon (*O. keta*) of the Cowichan river, one important feature being to determine the extent to which these fish, from a comparatively minor river system, contribute to the commercial fishery.

By recording the adult returns to, and fingerling escapements from two small adjacent coho spawning streams in the Cowichan River system, data on natural spawning and survival of the young are being collected.

Herring. The herring fishery is an important one in British Columbia. For some years it has been carried on in the southern waters of the Province, i.e., along the west coast of Vancouver Island and in the Strait of Georgia to the east. Latterly a fishery in northern waters has developed. It was desired to know whether these several geographically separate fisheries composed one homogeneous population, or whether they were distinct and to what degree. Racial studies, based on vertebral counts, size of individuals, age classes, and rates of growth, indicated that the populations in the main areas were relatively distinct and subsequent tagging programs have confirmed this. Only a small degree of inter-mingling between major areas has been found. Attention is being given to the relation of extent of spawning to the subsequent appearance of individual year classes, the rate of natural mortality and the reaction of the population of fishing drain, particularly to reveal the optimum degree of commercial exploitation which the species might withstand without decline in abundance resulting. A system of five year quotas has been devised in an effort to experimentally stabilize the fishery and to check the reaction of the population to it, but war conditions and the demand for food fish has interfered. Each year samples of the catches in all areas are obtained, size frequencies computed and age classes analyzed. Dr. A. L. Tester is in charge of this research, assisted by Dr. R. V. Boughton.

Pilchard. The pilchard research, under the direction of Dr. J. L. Hart, is largely a matter of taking regular samples of the commercial catch, obtaining size frequencies and age classes and making comparison with former years to reveal the trends of the populations. A certain amount of tagging has been done in former years and has revealed a definite relationship between the pilchards caught off the British Columbia and California coasts. The data suggest that the variability in the pilchard fishery off British Columbia depends upon the magnitude and age composition of the general population in the waters off California and upon the occurrence of favourable hydrographic conditions since indications are that the older fish of the population come as far north as British Columbia.

Ling Cod. The research into the ling cod fishery, also conducted by Dr. Hart, has, up to the present, been largely a matter of studying migration by means of tagging, distribution, rate of growth and compiling statistics related to the fishery. To date, no extensive migration has been indicated, the fish apparently remaining in close proximity to their natal or chosen feeding ground.

Shellfish. With reference to clams, the chief study has been made of the species which is canned, *Saxidomus giganteus,* the main objective

being to obtain information which will place the fishery regulations upon a sounder basis. In certain areas signs of a decline in abundance have appeared and the most suitable and efficient means of rectifying the situation are desired. By setting up experimental Latin square plots in representative clam beaches of the coast various degrees of exploitation are being tested, e.g., digging twice a year, once a year, every two years, every three years, etc., and the results compared. It has been found that year classes are very unevenly represented in most of the beds, and in many cases very young clams are rare. It would seem that in this fishery, as in so many others, dominance of certain year classes plays a very important part and contributes largely to the variability of the fishery.

The oyster research has been confined to a study of the Pacific oyster (*Ostrea gigas*) and, in particular, to the factors which limit the survival of the larvae and the successful setting of the spat. With Japanese sources of seed oysters now unavailable, recourse must be had to obtaining seed locally, and since under natural conditions the supply of seed is extremely unreliable, certain experiments in production of seed under partially controlled tank conditions are being undertaken.

In conclusion, perhaps a brief list of the papers prepared by the Station staff during 1942 to date may indicate the extent of the work in hand. Among the scientific papers either published or submitted for publication were: "The effect of reduction of predaceous fish on survival of young sockeye salmon at Cultus lake," by R. E. Foerster and W. E. Ricker; "Growth of the Rocky Mountain Whitefish," by J. L. McHugh; "Variation of vertebral centra in young Pacific herring (*Clupea pallasii*)," by J. L. McHugh; "Surface non-tidal currents in the approaches to Juan de Fuca strait," by J. P. Tully; "Food of the rainbow, cut-throat and brown trout in the Cowichan river system," by C. Idyll; "Vertebral number of young herring in southern British Columbia," by J. L. McHugh; "The Pacific edible crab, *Cancer magister*," by D. C. G. MacKay; "The Smelts (*Osmeridae*) of British Columbia," by J. L. Hart and J. L. McHugh; "The Butter Clam (*Saxidomus giganteus* Deshayes)"; Studies in Productivity," by Ferris Neave; "The Tagging of Pilchards: Insertions and Recoveries, 1941," by J. L. Hart; "The Tagging of Herring: Insertions and Recoveries, 1941," by J. L. Hart, A. L. Tester, R. V. Boughton and J. L. McHugh. Among more popular articles prepared (Progress Reports) were: "Recoveries of Cowichan River coho salmon from the 1938 brood year emphasize the value of marking experiments," by Ferris Neave and A. L. Pritchard; "Reproduction in the Dogfish," by J. L. Hart; "Sand Fleas and Live Bait," by J. L. Hart; "Albacore food," by J. L. Hart; "The food of spring salmon in British Columbia," by A. L. Pritchard and A. L. Tester; "Mortality of herring," by A. L. Tester; "Dogfish tagging—preliminary results," by R. E. Foerster.

DIFFERENTIAL EFFECTS ON THE MASS AND TIME OF APPEARANCE OF REGENERANTS IN TUBULARIA

S. Spiegelman

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This particular aspect of the regeneration problem started from a relatively simple and apparently uncomplicated investigation.

Barth in 1938 showed that oxygen could be made a limiting factor in the regeneration of new hydranths as well as in the dominance and polarity of the stems of Tubularia. He also showed (Barth, 1940) that paralleling the fall in regeneration at low oxygen tensions there was a decrease in the Q_{O_2}.

Goldin in 1942 showed that regeneration rate could be modified by varying the pH of the sea water in which they were placed. It was of some interest to see whether the decreased regeneration rate at low hydrogen ion concentrations was also accompanied by a decrease in Q_{O_2} as in the case of low oxygen tensions, especially since Moog and Spiegelman (1942) found that a complete blocking of the process of regeneration could be obtained without any concomitant measurable effect on the respiratory rates. Accordingly, in collaboration with Dr. Goldin, experiments were performed with the purpose of measuring the rate of oxygen uptake at different hydrogen ion concentrations and comparing them with regeneration rates at the same pH.

The results were satisfyingly clear-cut. There was a 73% drop in the rate of respiration through the range of pH from 8.0 to 6.6. In this same range the regeneration rate fell to 1% of its value at pH 8.0. A comparison of the oxygen and pH data shows a similarity of their effects on both regeneration and respiration. A pleasingly direct conclusion was open to us; namely, that the effect of pH on regeneration was a non-specific one being mediated through its effect on the over-all oxygen consumption.

However, the adequacy of such a simple comparison of the two sets of data is questionable, due to the necessary arbitrariness of the method chosen to measure rates of regeneration. As for-

(Continued on page 73)

The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Judy Woodring and Jane Woodring.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

THE RECLAMATION OF AGAR

Agar, a jelly-like substance made from seaweed, has been one of the wartime casualties of the laboratory. It is practically a "must" material in certain kinds of laboratory culture, especially in bacteriology, so that the cutting off of its pre-war source, Japan, threatens considerable inconvenience to research workers.

Methods for reclaiming once-used agar for re-use are described in a late issue of *Science* by two Washington research workers who worked out their processes independently of each other. The men are Dr. Alden F. Roe of the George Washington University School of Medicine and Dr. Howard I. Thaller of the U. S. Department of Agriculture laboratories at Beltsville, Md. outside this city.

There are some differences between the two methods, but both share certain essential steps. The discarded cultures are killed by heating thoroughly in a pressure chamber (autoclave), then the melted agar is poured into vessels and the debris removed either by filtering or sedimentation. Finally the jelly-like substance is slowly dried until it is reduced to hard, half-horny sheets that can be stored indefinitely in a dry place. To re-use, it is boiled in water and colled to the jelly form desired.

Agar has recently come into considerable demand for a "bulk-former" in certain kinds of medicine, but this use is of course stopped entirely now. Laboratory requirements have priority.

Some substitutes for agar have been found, though these are not yet wholly satisfactory to many bacteriologists. A certain amount is also being produced from seaweed in this country, but probably not enough to replace the former imports from Japan.—*Science Service.*

"Marine Life at Woods Hole" is the subject of the 800 feet of moving pictures and fifty stills which Mr. George G. Lower will show in the auditorium of the Marine Biological Laboratory this afternoon at 4:00.

Members of the National Academy of Sciences who are at Woods Hole this summer are: Dr. G. N. Calkins, Columbia; Dr. E. N. Harvey, Princeton; Dr. M. H. Jacobs, Pennsylvania; Dr. T. H. Morgan, California Institute of Technology; Dr. L. L. Woodruff, Yale; Dr. E. G. Conklin, Princeton; Dr. W. J. V. Osterhout, Rockefeller Institute; Dr. E. F. DuBois, Cornell; Dr. S. A. Waksman, New Jersey Agricultural Experiment Station.

ADDITIONAL INVESTIGATORS

Bartlett, Jr., J. H. assoc. prof. physics. Illinois. OM 43.

Bissonette, T. H. prof. biol. Trinity. Br 318.

Bloch, R. res. assoc. bot. Yale. Lib.

Bond, Christiana B. sec. Maryland Med. Br 304.

Everett, G. M. res. fel. Maryland Med. Br 304.

Fowler, Coleen grad. Hopkins. Lib.

Hecht, M. res. assoc. Maryland Med. Br 304.

Jacobs, Joye E. asst. Maryland Med. Br 304.

McClung, C. E. prof. zool. Pennsylvania. Br 219.

Newell, J. W. Cornell Med. Lib.

Oster, R. H. asst. prof. phys. Maryland Med. Br 304.

Scott, A. C. asst. prof. biol. Union. Br 121-A.

Schwartzman, G. head dept. bact. Mt. Sinai Hosp. Lib.

Thivy, Francesca grad. Michigan. OM 21.

CURRENTS IN THE HOLE

At the following hours (Eastern War Time) the current in the Hole turns to run from Buzzards Bay to Vineyard Sound:

Date	A. M.	P. M.
August 15	6:43	7:03
August 16	7:26	7:49
August 17	8:11	8:39
August 18	9:01	9:34
August 19	9:54	10:32
August 20	10:52	...
August 21	11:33	11:52
August 22	12:35	12:54
August 23	1:36	1:53
August 24	2:33	2:50
August 25	3:27	3:44
August 26	4:18	4:36
August 27	5:06	5:25
August 28	5:53	6:13
August 29	6:38	7:01
August 30	7:24	7:50
August 31	8:11	8:40

In each case the current changes approximately six hours later and runs from the Sound to the Bay.

ITEMS OF INTEREST

At the annual meeting of the Marine Biological Laboratory on August 11, Lawrason Riggs was elected President of the Corporation and Chairman of the Board of Trustees to fill the vacancy left by the resignation of Dr. Frank R. Lillie, who was made president emeritus. The newly-created position of vice-president was filled by the election of Dr. E. Newton Harvey. Donald M. Brodie was selected to replace Mr. Riggs as Treasurer. Dr. O. C. Glaser succeeds Dr. Philip B. Armstrong as Clerk of the Corporation.

Two trustees, Dr. S. O. Mast and Dr. Albert P. Mathews, having passed the age of seventy years, were elected to the emeritus class. In their places Dr. Eric G. Ball of the Harvard Medical School and Dr. Eugene F. Dubois of the Cornell University Medical College were elected. All eight trustees whose terms expired this year were renominated and elected to serve for another four-year period. Dr. O. C. Glaser and Dr. C. W. Metz have been appointed members of the Executive Committee of the Board of Trustees. They succeed Dr. P. B. Armstrong and Dr. W. C. Allee.

Dr. Francesca Thivy, now working at Woods Hole, has named a new species of alga of the genus Ectochaete, which she discovered recently, after Dr. Wm. Randolph Taylor, who directs the work in botany at the Marine Biological Laboratory. This new species of alga is to be known as *Ectochaete Taylori.*

At the annual meeting of the trustees of the Oceanographic Institution on Wednesday, Dr. Alfred C. Redfield was elected associate director. The six trustees whose terms expired this year were elected to serve for another four-year term.

Among the trustees of the Laboratory who came from out of town to attend the annual meeting were Drs. B. H. Willier, W. B. Scott and Ross G. Harrison.

On Tuesday the trustees of the Marine Biological Laboratory ate their annual dinner at the M.B.L. Club. It was not served in the Mess Hall this summer owing to the crowded conditions which prevail in its temporary quarters at the Nobska Inn.

Dr. Daniel Harris, who completed his work for a doctor's degree in the Department of Zoology at the University of Pennsylvania, has been awarded a National Research Council fellowship. He will work under Dr. Carl L. A. Schmidt, professor of biochemistry at the University of California.

Dr. Karl M. Wilbur, instructor in zoology at Ohio State University, has been appointed assistant professor of physiology at Dalhousie University, Nova Scotia. He succeeds Dr. Hugh Davson who has returned to England.

Dr. and Mrs. D. E. Lancefield visited Woods Hole for ten days at the beginning of August, leaving last Monday. Mrs. Lancefield has been promoted from associate to associate member at the Rockefeller Institute for Medical Research.

Dr. Paul Speigelman of Columbia University will join Dr. Hamburger as assistant in zoology at the University of Washington this fall.

Dr. Lorande L. Woodruff, professor of protozoology at Yale University, has been elected an honorary member of the Sociedad Mexicana de Hisotria Natural.

Dr. George H. Parker spent two or three days at Woods Hole at the beginning of last week. It is the first time for a number of summers that he has been unable to work at the Laboratory.

Dr. H. H. Plough, who was professor of biology at Amherst College, is now a Captain in the Sanitary Corps in the U. S. Army and in charge of bacteriology at the Lovell General Hospital at Fort Devens.

Dr. and Mrs. D. B. Keyes and their daughter Nancy arrived last Tuesday for a ten-day visit in Woods Hole. Dr. Keyes is professor of chemical engineering and head of the division at the University of Illinois.

The engagement of Galina Gorokhoff and J. Philip Trinkaus was announced in April at Smith College where Miss Gorokhoff is a senior. No definite plans have been set for the wedding. Miss Gorokhoff is the daughter of Professor I. T. Gorokhoff of Smith College.

Besides the investigators mentioned in the last number of The Collecting Net, the following men from Woods Hole are working at Randolph Field: Drs. Leon Churney, Sam Coursan, Alexander Barry, H. J. Evans and Charles Lyman.

On August 13 there were 144 investigators at the Marine Biological Laboratory—178 less than on the same day last year.

The following investigators at the Laboratory have left Woods Hole: H. B. Baker, L. V. Beck, H. Shapiro, R. M. Eakin, H. J. Hohwieler, R. Rugh, P. Levine, L. K. Diamond, Hannah Croasdale and R. K. Cannan.

SOME EFFECTS OF TEMPERATURE IN THE REGENERATION OF TUBULARIA

Florence Moog

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Although it was previously thought that in Tubularia the size of the regenerating hydranth and the rate of its differentiation were mutually dependent processes, recent studies by Spiegelman, Goldin and Moog have indicated that it is possible to affect the time factor to a considerable extent without producing any correlated change in the size factor. By the application of varying temperatures, however, it has proved possible to show that the two factors are actually capable of being shifted in opposite directions.

In the experiments reported here, temperatures of 7°, 10.8°, 13.5°, 18.7° and 20.8°C. were used. Throughout this range, the relation between temperature and velocity (considered as the inverse of the time to the appearance of a constriction between the primordium and the rest of the stem) is linear. The average Q_{10} was 1.8. The steepness of the lines varied directly with the velocity at the highest temperature, so that the most active material appeared to be the most susceptible to temperature retardation. If the rate of regeneration depends in part on the concentration of a substrate, as has been suggested by Barth (1940, *Biol. Rev., 15*: 405-420) and Spiegelman (unpublished), then the lessened susceptibility of sluggish material would mean that in such stems the rate is limited by inadequacy of available substrate.

The length of the primordia was increased from an average of 1024 micra at 20.8° to 1394 micra at 7°; the relation between the two factors took the form of a sigmoid curve with the rate of change diminishing at 10.8° and 18.7°. The Q_{10} for the effect, calculated according to the inverse of the usual formula, averaged 1.3, and was not affected significantly by the size or speed of the material. The probable meaning of this low Q_{10} is that the determination of size is limited principally by a physical process, most likely the diffusion of substrate or oxygen.

The possibility that oxygen alone is responsible for the temperature-size effect immediately suggests itself, for Barth (1938, *Physiol. Zool., 12*: 179-186) has shown that size varies directly with both increase and decrease of oxygen tension, and between 21° and 7° the oxygen content of sea water increases by about 30 per cent. The fact that raising the oxygen tension increases both size and velocity, however, indicates a fundamental difference in the temperature and oxygen effects. And furthermore, a change of 30 per cent in oxygen concentration is, according to Barth's figures, not nearly enough to account for a 35 per cent increase in size.

A more likely explanation then is that the effect of temperature on size is linked to the effect on rate of formation. On the one hand temperature decrease probably cuts the rate by acting on the velocities of the processes involved, while on the other hand it would not interfere much with the diffusion of oxygen or substrate into the active region. Thus lowering the temperature would allow the regenerating region to draw on a uniform supply of materials at a retarded rate. The net effect would be to increase the supply of oxygen or substrate, and so a larger structure might result. This is the same line of reasoning as Gray (1928, *J. Exp. Biol., 6*: 125) used in explaining his findings that trout embryos raised at low temperatures are larger at a given stage than those raised at high temperatures.

A third question that arises is whether the bigger hydranth regenerated in the cold is merely a magnification of the hydranth under warmer conditions, or whether temperature change exerts a differential effect on the parts of the structure. Because there are numerous examples of unequal temperature effects during ontogeny, it was thought that the discovery of similar effects here might indicate the existence of processes, underlying regeneration, that are not harmoniously interdependent.

Accordingly counts were made of tentacle numbers in newly regenerated hydranths, fifty to seventy being counted at each temperature. The number of tentacles in the oral circlet was found to increase from 11.7 at 21° to 13.7 at 7°, while the number in the basal circlet decreased from 13.3 to 11.2 over the same range. Although the differences in the numbers did not quite satisfy statistical tests of significance, the fact that there was in both circlets a clearly evident trend of increase and decrease from one end of the range to the other, rather than a random scattering of points, indicates that the differences were in reality significant. Probably the high variability was due to the fact that the counts were made on numerous small samples of genetically diverse material. Experiments on genetically controlled material are now being made to test this point.

The ratio of the oral to basal tentacles also shifted from 0.88 at 21° to 1.22 at 7°, and in this case the differences proved to be very significant. On the basis of this evidence that the ratio is stable at any one temperature, it was decided to test the tendency of the two circles to maintain a fixed ratio by determining their correlation coefficients. The values of the coefficients were 0.338 at 20.8°, 0.289 at 13.5°, 0.341 at 7°; the significance of these correlations was proved by the fact

that all gave probability values of less than 0.02.

One may conclude, therefore, that the processes determining the number of tentacles in each circlet are interdependent and correlated. It appears from the data that with falling temperature the more distal, or oral, portion of the stem becomes dominant over the basal section. It is not now clear, however, whether this "dominance" is an intensification of the normal dominance exerted by the distal over the proximal end of the stem, or whether it is a local situation, perhaps related to the diffusion of oxygen in from the cut surface.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 4.)

DIFFERENTIAL EFFECTS ON THE MASS AND TIME OF APPEARANCE OF REGENERANTS IN TUBULARIA

(Continued from page 69)

mulated by Barth (1938) the rate of regeneration is defined by the ratio L/t where L is the length of the regenerating primordium and t is the time in hours from the moment at which the stem is cut to the stage when a constriction appears between the primordium and the rest of the stem. Previous investigators, Child (1941), Miller (1937) and Moore (1910), have been content to use 1/t as a measure of the rate of regeneration. Child, in his book "Patterns and Problems of Development," questions the validity of including the length in the rate of measurement. However, as will be seen presently, the utilization of the 1/t definition of rate necessarily ignores an important aspect of the phenomenon.

To return to Barth's definition it will be noted that the t is not one such as is found in ordinary rate formulae. It is unique in the sense that it is determined by a stage in the history of a developing system and its use yields a rate which is the average of many processes leading to the stage defining it.

The mass of the primordium formed is proportional to $\pi r^2 L$, where r is its radius and L its length. Therefore the L in the definition is proportional to the mass of the regenerating tissue. It is thus seen that two distinct factors are combined in the ratio, one being the mass of tissue transformed into hydranth and the other, the time necessary to arrive at a particular morphological event in the process. It is clear that the rate of regeneration may be varied either by affecting separately the mass of tissue involved, or the time to constriction or both simultaneously. There is, therefore, no a priori reason for believing that regeneration rates modified by different reagents or even various concentrations of the same reagent are directly comparable since the same resultant rate could be obtained in several different ways involving entirely different mechanism. If this is true then similar effects on rates by two agents does not necessarily imply that they are acting through the same mechanism.

To test whether a separation of the mass and time factors is experimentally realized plots were made of Barth's (1938) data which permitted an examination of the effects of oxygen tension variation on each of these factors. From this examination it was immediately apparent that the dominant effect of increased oxygen tension is on the mass of tissue involved in the regenerant, the time to restriction being unaffected. There is thus a considerable range in which the increase in the L/t rate is obtained solely by a change in the mass factor. It is, of course, obvious that the use of the 1/t definition would have completely missed this finding.

A similar plot of the pH data revealed that although the same kind of L/t curve is obtained, the method of attainment is entirely different. In this case over the entire range both the mass and the time were strongly effected.

The significance of this differential effect is not immediately clear, nor was the operation which involved a separate study of two factors of a rate. At the suggestion of Dr. Steinbach the whole problem was reëxamined more carefully. Experimentally it was desirable to see how widespread this phenomenon was. Accordingly with the collaboration of Miss F. Moog the differential effect of various inhibitors were studied. We will cite only two representative experiments.

In the case of ethyl urethane over a concentration range which yielded a 67% decrease in the time factor, the mass factor was increased by 11%. The resulting effect, of course, being a decrease in the L/t curve. In the case of cyanide over a concentration range which yielded over a 200% decrease in the 1/t factor, no significant change occurred in the mass.

Whatever be the final interpretation of these results it is obvious that under certain circumstances the 1/t definition of rate so commonly used is inadequate, and if the whole story is to be obtained both the mass and the time must be considered.

It seems reasonable to assume that regeneration involves the synthesis of compounds which require the continual expenditure of energy both for their formation and continued existence. If this is true a possible method of approaching the interpretation of the differential effects on mass and time may be made in terms of the properties of an energy yielding system approaching the steady

state. Such a system may be briefly exemplified by

$$S \overset{k_0}{\leftrightarrow} A \overset{k_1}{\rightarrow} B \leftrightarrow Z$$

where S is a source of A whose transformation into B yields the energy for the synthesis and Z is a sink for B. Without going into the mathematical details it is possible to show that the level of the rate of energy production, or what is equivalent, the concentration level of the substance synthesized is given by

$$L = M - Ne^{-(k_0 + k_1)t} ,$$

where M is a function of the velocity constants k_0 and k_1 and N has the form

$$N = [C_{AO} - f(k_0, k_1)] .$$

C_{AO} is the concentration of A at zero time and does not appear in the M which is a measure of the mass of substance finally formed. An experimental procedure that changes the value of C_{AO} would not influence the amount of substance finally synthesized but would effect only the time necessary to approach the final time-independent state. On the other hand large variations in the velocity constants (k_0 or k_1) would effect both factors strongly. A more detailed analysis indicates that differential effects may be obtained with small variations in these constants since they are involved in an exponential as well as an algebraic term.

One more point of interest may be mentioned. According to Child's concept of rate, the time to constriction and the mass of the regenerant are essentially independent. That is to say, if one plots mass versus time of appearance in a population undergoing the same treatment one should get a straight line parallel to the time axis. However, the theory briefly indicated above predicts that in an experimental procedure which effects both mass and time strongly, e.g., through the velocity constants, the size should vary inversely as the time taken to arrive at the constriction stage. Experiments with chloretone which effects both mass and time confirm this prediction.

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(This article is based upon a seminar report given at the Marine Biological Laboratory on August 4.)

INVERTEBRATE CLASS NOTES

The staff has continued this week to throw the work at the Invert students, leaving them little time to stop and catch their breath. The lectures on the Platyhelminthes were particularly interesting and well-organized, and a comprehensive survey of the phylum was worked out in the laboratory, with the emphasis placed on the physical and physiological changes occurring in the Platyhelminthes, concurrent with the increase in the degree of parasitism.

In regard to the reports on the field trips, some modifications have been made, after examination and comparison of the first lot. Various suggestions by the staff were made to facilitate conciseness and at the same time to obtain completeness of detail. The idea of reports is an excellent one and has worked out very well.

Last Thursday evening, Dr. Taylor of the botany department showed several reels of color film under the general heading of "The Tidal Pools of the Woods Hole Region," showing a variegated collection of the flora found here. The photography was excellent, and Dr. Taylor's selection of specimens and groups was certainly a beautiful piece of work.

Somewhat in accord with the several experiments on the Molluscan heart which have been carried out in the laboratory, was the lecture by Dr. Ralph Smith on the "Pharmacology of the Arthropod Heart." He stated that his work to date had seemed to indicate that the cause of heart beat inhibition was a discharge by nerve endings in the heart of a substance which might be acetylcholine. He did seem fairly sure that this substance was present when inhibition occurred, but whether or not it was discharged by nerve endings was not definite as yet. This aspect of the work on the invertebrate heart is relatively recent and a tremendous amount of work remains to be done. It seems that the solution to the problem of heart action will be found in the field of comparative physiology because the biochemical set-ups seem to vary tremendously in different species. Dr. Smith warned of the danger of depending on any homology between the pharmacology of the vertebrates and the invertebrates, because in many cases effects will be entirely different or even nonexistent. The general question of how the heart works is a puzzling one, but at present it seems that ganglionic action associated with neural secretions are the governing factors. Dr. Smith stressed in general the point that the field of com-

parative physiology is not densely populated, and that a great deal of work is possible in connection with it.

A new specimen wandered into the lab the other night, in the person of one "Mildew," a bedraggled kitten which Dick Emerson assisted in escaping the dissection knife in the physiology lab. Mildew wasted no time in settling down, and promptly proceeded to gobble up some choice *Fundulus heteroclitus*.

But then again Mildew has nothing on the fair Woodie whose insatiable appetite has amazed and bewildered even the huskiest male biologists. And speaking of shocks, Marge Brearley got a double charge last week—but she has, to all indications, recovered quite nicely.

Headlines and just lines . . . Taft's cure for the sniffles is making the rounds . . . Stan has a new interest upstairs . . . Lorentz lost his gas ration card and is now breaking in practically new and unusued legs on Main and Water Streets . . . Buck Winchellating on the Bryozoa . . . the Navy loses its sea legs and pops into the lab for a midnight visit . . . what prof is cramming frantically on the Annelida two days before lectures on same . . . who is the Frank Munn of the field trips? . . . something we'll never see—Dr. Hewatt without his "bugs"—Edie Cole in the Invert Lab . . .

—*N. W. F. and E. C.*

BOTANY CLASS NOTES

August first brought the official end of the 1942 Botany Class. Our last days were devoted to an intensive study of more than thirty genera of the Rhodophyceae, all collected in the vicinity of Woods Hole. In his lecture on the economic significance of the red algae, Dr. Taylor described the production of agar from *Chondrus crispus*, or Irish moss, and extracted some of the crude gelatin. He also segregated the pigment phycoerythrin from one of the more delicate red algae.

The last trip of the season was scheduled for Tuesday; and, despite the fog, several members, prepared for the trip with bathing-suits and buckets, arrived at the Mess at eight o'clock, much to the amusement of the rest, who assured us that the trip had been postponed. Great was our surprise and elation at the close of Dr. Taylor's lecture, an hour later, to find the fog lifting and Amos standing at the door asking whether we still wanted to go to Black Rock. Dr. Taylor's last words were lost to posterity as he joined the mad scramble for sweaters, buckets and lunch. We left the Eel Pond at 9:45 and arrived in New Bedford Harbor in time for a good morning's collecting before lunch. Specimens on the rocks and in nearby waters were varied and in excellent condition. The ecological progression along the rock from low to high tide marks made an interesting and colorful study. When the embarkation by rowboat was completed, and the *Nereis* ready to leave, someone luckily looked back and noticed one greedy algologist who had been left astride an obscure rock, grappling feverishly for Ahnfeltia between breakers. The rescue was quickly effected, and the class returned from its last trip with enough algae to make a three foot pile of mounts in the press.

The day of the trip was the final meeting of the entire Class, for Ed returned to find a telegram from Uncle Sam and left the next morning for the Coast Guard Academy at New London. The rest of the Class worked steadily finishing up drawings and filling out collections until noon Saturday. After a short flurry of cleaning up and packing off scopes, our week-end began that afternoon with relaxing on the beach and sailing in the Harbor. Saturday evening, we were in the Lab preparing a few odd mounts, when the inevitable occurred. Someone, mentioning no names, picked up a rubber plunger filled with water, and the others rose to the occasion. The four active participants were quickly drenched to the skin, and one member of the class proved to be no mean slinger of Polysiphonia when cut off from other ammunition. H. Arrowsmith, shooting from behind a packing box with a plunger in each hand, displayed his famous two-gun technique to good advantage. After three attempts, a truce was finally established, and a really bang-up cleaning job, under the direction of John Paull, was done on the Lab.

Driving to New York City Monday morning with Trink were Margy, John, seven suitcases, and a hat box. We are still wondering how much of a traffic jam they caused en route to Penn Station in the subway. Margy will return to her senior year at Goucher after working the rest of the summer in an agricultural experiment station. When John receives his degree from Washington and Jefferson in December, he will enter the naval Training School Mary is in her last year at Smith College where she will do individual work in plant cytology. Peggy, working for her M.A., and Jane, for her B.A., will continue to botanize together at Wellesley. Harold expects to continue his botanical studies at Minnesota. Eunice's splendid collection of marine algae will be a great help to her and to the rest of the Botany staff at Kansas State this year.

And now that the Class has dispersed for good, we should all like to express our thanks to Dr. Taylor, Dr. Croasdale, and the others who have helped to make Botany the grand course it is.

—*J. B.*

THE COLLECTING NET

Vol. XVII, No. 5 SATURDAY, AUGUST 29, 1942 Annual Subscription, $1.00 Single Copies, 30 Cents.

THE OFFICIAL MEETINGS OF THE MARINE BIOLOGICAL LABORATORY

DR. CHARLES PACKARD
Director,
The Marine Biological Laboratory

The meetings of the Corporation and Trustees this year were of special significance for they mark the end of Dr. F. R. Lillie's long and fruitful service as an active officer, and the beginning of Mr. Rigg's term as President. Dr. Lillie came to Woods Hole as a beginning investigator in 1891. Nine years later he was made Assistant Director, and after Dr. Whitman's death in 1908, he became Director. During the years that followed, this institution, under his guidance, grew rapidly in prestige and in size. When the extensive building program, which gave us the Brick Building, the Dormitory and the Apartment House, was completed in 1925, he retired as Director and was made President of the Corporation, a position which he has held until now. Thus, he has seen the Laboratory grow from infancy to maturity, and during the intervening years has played a very large part in shaping its policies. It is our good fortune that he will continue to work here and advise those who in the past have relied on his sound judgment and foresight.

To succeed him the Trustees named as President, Mr. Lawrason Riggs, for the past eighteen years our Treasurer. The precedent of having a non-biologist in this position was set many years ago when Mr. C. R. Crane, the generous patron of the Laboratory, was (*Continued on Page* 93)

CONTRACTILE MECHANISM IN UNICELLULAR PIGMENTARY EFFECTORS

DR. DOUGLAS A. MARSLAND
Associate Professor of Biology, Washington Square College, New York University

How the pigment granules flow out into the branches of the melanophores—when a fish such as Fundulus darkens to correspond with its background—and how these same granules are brought back to the centers of the cells—when the specimen becomes adapted to a light background—are questions which have interested physiologists for many years. Recently considerable evidence bearing on these questions has been obtained from observations on the behavior of melanophores under hydrostatic compression.

Previous studies have demonstrated that hydrostatic pressure in the range up to 800 lbs./in^2, inhibits protoplasmic gelation reactions in cells generally, and also that certain types of protoplasmic movement (amoeboid movement, the cleavage furrowing of egg cells and streaming in plant cells) are simultaneously inhibited to a corresponding degree. The conclusion that contractility is a direct function of protoplasmic gelation seems to be justified and this hypothesis has been tested in the melanophore studies.

Observing the contracted melanophores of a scale of Fundulus, isolated in N/10 KCl solution in a pressure chamber, it can be seen that each increase (1000 lbs/in^2) of pressure is accompanied by a regular and definite partial expansion. At 2500-3000 lbs., the half-expanded point is

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reached, and at 7000-7500 lbs., full expansion invariably occurs. These changes are freely reversible. Other conditions remaining the same, each pressure determines a certain contractile state, regardless of whether this is reached by increasing or decreasing the pressure level. Futhermore, in a qualitative sense at least, the pressure inhibition of the contraction phase of the melanophore parallels the inhibition of protoplasmic gelation, observed in other cells.

Similar results are obtained when one observes the effects of pressure upon melanophores which have been induced (by the method of Spaeth) to pulsate. At lower pressures, the pulsations continue, but in restricted fashion. Always the expansion phase reaches completion, since the pigment granules always flow out to the very tips of the branches, but the contraction phase becomes more and more restricted as the pressure is increased. At 3000 lbs., for example, the inflowing granules only reach the "half way" point before reversing direction, and at 7000 lbs., while the pressure is maintained, the pulsations cease, each melanophore being in a fully expanded condition.

Since Parker has demonstrated that the dispersing and concentrating fibres of the nerve supply of the melanophores survive after severance of the central connections, it seemed necessary to repeat the foregoing experiments on completely denervated specimens. This would eliminate any indirect effects of pressure upon the nervous tissue. Small pieces of the tail fin, taken ten days after severing the corresponding tail nerves, i.e., after complete degeneration was assured, were used for these experiments. The results with denervated melanophores corresponded exactly with the observations on the other specimens. Therefore, it is certain that the pressure effects are localized in the melanophores *per se*.

Measurement of the pressure inhibition of gelation—similar to the measurements obtained in other cells—could not be made in the melanophores, due partly to their unusual shape, but mainly to the fact that the protoplasmic gel in melanophores is much stiffer than in the cells previously studied. At 20,000 gravity (the maximum centrifugal force possible with the existing pressure-centrifuge apparatus) no pigment displacement could be observed in melanophores, either in the contracted or expanded condition. However, with 80,000 gravity (air turbine centrifuge), pigment displacement was always obtained in expanded specimens (in NaCl, acetylcholine and physostigmine solutions), but never in contracted specimens (in KCl and adrenalin solutions). Thus it may be concluded that the protoplasm is more firmly gelled in the contracted than in the expanded melanophore.

The assumption that the contractile phase of the pigmentary response is mediated by protoplasmic gelation is further strengthened by observing the effects of temperature. At room temperature contraction is regularly obtained in N/10 KCl, and expansion in N/10 NaCl. At 6° C, however, the KCl specimens begin to expand slowly, with maximum expansion ensuing within 30 mins.; and at 32° C, the NaCl specimens contract to a maximum in about the same time. In this connection it must be remembered that all of the protoplasmic gels studied display a behavior which is quite opposite to that of gelatin. These cellular gels, instead, have their counterpart in such gels as methyl cellulose and myosin. In this group, gelation is fostered by increasing (rather than by decreasing) temperature, and by decreasing (rather than by increasing) pressure.

In summary it may be said that the evidence supports the hypothesis that the contraction of the melanophore—whereby the pigment granules are withdrawn from the outlying branches of the cell—is mediated by gelation of the protoplasm. All factors which foster the gelation reaction—decreasing pressure, increasing temperature and the application of chemical agencies such as KCl and adrenalin—likewise foster contraction. In the case of pressure, the degree of the contraction conforms with expectations, at least in a qualitative sense. Comparing the melanophore with an amoeboid cell, the clear region which can be seen in the center of expanded and half-expanded specimens, probably represents the fluid plasmasol, which is surrounded by the pigment-laden plasmagel. During the contraction of the plasmagel, it appears as though the hyaline plasmasol is squeezed forth into the outlying branches, replacing the pigmented plasmagel as this retreats from the branches.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 18).

THE STRUCTURE OF BIOLOGICALLY ACTIVE MEMBRANES

Dr. Dorothy Wrinch
Smith College

The membranes under consideration are plasma membranes. They are flexible, highly specific and contain a protein component. In biological problems of the utmost diversity, high specificity has been traced so often to the proteins, that it is reasonable to see first what their presence in the plasma membrane implies. This point has been re-emphasized with telling effect in a recent paper by F. O. Schmitt (*Third Growth Symposium*, 5, 1, 1941).

Among the vast array of proteins, only those in native state evince high specificity. For the proteins in the living cell membrane therefore we must assume the native state. Thus we can make no distinction between the proteins in the surface and those located within the body of the cell. Native proteins wherever they occur are characterized by their ability to form associations. These substances, it appears from immunochemistry, physical chemistry and crystallography, are genuine molecules despite their large molecular weight. They have "globulite" skeletons, i.e., highly organized and therefore multiply-connected atomic cores, embodying the esssential C-Cα-N rhythm of the amino acids. All this may be surmised from detailed x-ray diagrams of various native proteins (*Fankuchen, Annals N. Y. Ac. of Sci.* 41, 157, 1941) and from diagrams of protein crystals containing varying complements of water (*Crowfoot et al., Nature* 141, 521, 1938). The most illuminating case perhaps is tobacco mosaic virus, (*Bernal and Fankuchen, J. Gen. Physiol.*, 25, 111, 1941) in which the long rod-like particle is not fibrous but is composed of globulites (about 20 Å or 10 Å in diameter) arranged in a definite pattern.

On its surface each globulite skeleton carries some or all of the Cα atoms in which the emerging R-groups of the amino acid residues are rooted. The nature and spatial patterns of these residues determine specificity. In crystals the rigid cores of the molecular units interlink by means of their R-groups. These, as protein crystals in different states of hydration show, are flexible. Such flexibility is shown by all native proteins so far studied.

Taken altogether, these results may be regarded as the first clear indication of the molecular basis for specificity and flexibility in plasma membranes and for the phenomena of plasmolysis. In our membranes the molecules associate to form a skin or shell. A working model results if we imagine the highly associated molecules of the insulin crystal, each interlinked with 8 neighbors, replaced by a closed surface distribution in which each protein unit has 3 or perhaps 6 neighbors. The slightly flexible crystal will now be replaced by a structure no less specific but of far greater flexibility.

This picture of the plasma membrane has implications. The interlinks of the network are of various types. Highly polar interlinks in which

"The Collecting Net" was entered as second-class matter July 11, 1935, at the Post Office at Woods Hole, Mass., under the Act of March 3, 1879, and was re-entered on July 23, 1938. It is devoted to the scientific work at marine biological laboratories. It is published bi-weekly between July 1 and September 1 from Woods Hole, and is printed at The Darwin Press, New Bedford, Mass. Its editorial offices are situated in Woods Hole, Mass. Single copies, 30c; subscription, $1.00.

hydroxyl, carboxyl, amino or acid amide groupings are bridged by hydrogen or rivetted by metallic ions, require definite interdistances and orientations of the atoms involved. These somewhat exacting geometrical conditions impose a rather open structure, shown, e.g., by the low density of ice. In fact in the neighborhood of its polar interlinks our membrane should have pores. By the standard for covalent bonds, the polar interlinks are necessarily weak. Hence, as is clear from Schoenheimer's striking results on proteins of the interior, the interlinks in the surface can also be made, unmade and made again, with a small expenditure of energy. Furthermore while fast in the presence of certain molecules, the interlinks will not be fast in the presence of others with groupings having higher affinities. The passage of foreign molecules through plasma membranes seems to hinge on issues of this kind. Thus glycine peptides decrease rapidly in water solubility with rising residue number, a fact never mentioned by protagonists of the earlier picture of proteins as immensely long peptide chains. Penta and hexaglycine are practically insoluble; but the strong affinity of CO-NH groupings for one another cannot hold in a sufficiently strong solution of urea. In this the glycines dissociate, thereby demonstrating a greater affinity of their interlinking polar groups for urea than for one another.

The other type of interlinking involves hydrocarbons. It lacks the stereochemical features of the more polar case and consists basically in as economical a use of space as possible with the various groupings cushioning together. The passage of foreign molecules of this type through membranes can also be accomplished on occasion, because of the (even smaller) energy of association of hydrocarbons. The distinctive differences discovered in such cases, as contrasted with the passage of polar molecules, can be most fruitfully studied in the light of the large body of data regarding the association of hydrocarbons obtained in crystal studies.

Most distinctive of all characteristics of plasma membranes is their activity. As C. V. Taylor phrased it in his recent lecture (*Collecting Net* 17, 41, 1942) "the essential nature of protoplasmic organization is that this organization is never static. It represents activity, continuous activity so long as life continues." As the dominant molecule in biological structures, the structure of the native protein may well offer definite suggestions regarding the nature of this activity. From the high perfection of the x-ray pictures of native protein crystals with high complements of water, we must presume that the molecules are interlinked not only with each other, but with many waters. All the evidence shows that native proteins not only can hold enormous quantities of foreign molecules of varied species in their R-groups and skeletons, but that stability itself depends on such associations.

If now the protein cytoskeleton within the cell and the membrane proteins are continuous, the mechanisms by which new units are incorporated to form new associations must be very similar. Whether protein or not, suitable units in solution in the protoplasmic interior can become parts of the membrane by association with the units already in position in the network and ready to receive newcomers because of the constant making, breaking and remaking of their interlinks. Indeed every plasma membrane is traceable to a pre-existing plasma membrane and has come about by the addition of new units to a pre-existing pattern. This pattern has places for more proteins, of the types already present, but is hospitable also to other species of molecules, including metallic ions and such preeminent membrane constituents as cholesterol and lecithin. On this picture, growth is fundamentally an expression of the high associability of native proteins and in a very real sense the "activity" of living matter may be attributed to the atomic architecture of the native proteins. It is possible that the incorporation of new types of molecule, perhaps of different native proteins, may be the actual cause of cell differentiation.

These facts make such studies as the structure analyses of the metallic hydroxides (*Bernal and Megaw, Proc. Roy. Soc. London* A151. 384, 1935) of direct relevance to our theme. As a model for heterotypic incorporation we refer to the various polycyclic hydrocarbons that build themselves into films of cholesterol (*Davis, Krahl and Clowes, J. A. C. S. 62*, 3080, 1940). In these studies, the knowledge of atomic architecture revealed by x-ray analysis made possible many discoveries regarding molecular specificities, as, for example, the fact that 1,2-benzanthracene can form associations within a cholesterol film but that anthracene cannot. To a biologist the definite stoichiometry which enables certain hydrocarbons to enter cholesterol films in the maximal proportion of 1 hydrocarbon to 2 sterols is most striking. Given a fuller extension of the powerful techniques of Langmuir, there is no apparent reason why these experiments should not be extended to cover mixed films of native proteins and other biologically significant ions and molecules.

We end then as we began. To understand any living structure, we must view it as an association of molecules and ions with geometrical, physical and chemical properties determined by an underlying protein theme. This theme cannot be set aside lightly, for the proteins are ubiquitious and their structure-determining powers in native form are approached by few other molecular species and rivalled by none.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 18).

THE EFFECT OF TEMPERATURE ON VERTEBRAL NUMBERS IN FUNDULUS

M. L. Gabriel
Department of Zoology, Columbia University

About eighty years ago, Günther (1862) and Gill (1863) first noted the fact that those species of fishes inhabiting tropical waters tend to have fewer vertebrae than related species from temperate or sub-arctic regions.

Since that time, many studies have been made on wild populations of fishes and two general facts have emerged: (1) There exist "geographic races" of fishes which are characterized, in part, by heritable differences in vertebral number. (2) Environmental conditions, particularly temperature, are associated with changes in the number of vertebrae, low temperatures usually being correlated with higher vertebral numbers.

These general facts have not, however, led to a clear understanding of the relative rôles of genetic and environmental factors and much less to an understanding of the mechanism underlying changes in vertebral number. The reason is that studies on wild populations involve two great difficulties. First, samples of collected fishes are of indeterminate genetic constitution. Second, the temperature during development is not known with sufficient accuracy. Some workers have used air temperatures, which frequently bear little relation to water temperature. Even where water temperatures are used, uncertainty as to the time of spawning makes it impossible to relate temperature at any time to exact stages of development.

It therefore seemed desirable to obtain more precise information on this problem by means of controlled laboratory experiments. Eggs of *Fundulus heteroclitus* were fertilized in the usual way, the parent pairs being fixed and saved. Eggs from each stripping were divided into three groups and raised until hatching in constant temperature baths at 24.5°C., 18.7°C. and 13.5°C., all sibs being kept separate. At the time of hatching, Fundulus larvae already have a well-ossified skeleton with the adult number of vertebrae, and in alizarin preparations the vertebrae can be readily counted.

Vertebral counts in teleosts are complicated by the frequent presence of so-called "fused" or "complex" vertebrae in which successive neural and haemal spines may be fused, or two centra may be wholly or partly fused. In the present work, for the purpose of counting a vertebra was defined as a set of arcualia, and such complexes were counted as two.

Data so far accumulated give information on a number of points. Sibs at any temperature differ from each other in mean vertebral numbers, and there are apparently sharp differences in the sensitivity of various sibs to temperature effects.

A very significant alteration of the vertebral number was produced under the temperature conditions imposed. The mean number of vertebrae is 32.73±.03 (S.E.) at 24.5°, 33.10±.04 at 18.7°, and rises to 33.44±.11 at 13.5°. Comparison of these means by "Student's" method gives t values of 3.12, 6.44, and 5.75 (P in each case is less than .01).

The shift in the mean is a reflection of progressive alterations in the skewness of the distributions. The relative frequency of fishes with 32 vertebrae decreases sharply at low temperatures, while cases with 34 and 35 vertebrae increase, the mode remaining at 33.

It is highly probable that temperature is an agent in producing such changes through its effect on the rate of development. At any given temperature, there is a considerable variation in rate of development. Study of a series of 980 fishes, all raised at 24.5°, showed a pronounced inverse relationship between rate of development and vertebral number. In these fishes, grouped according to time until hatching in two day intervals, the mean vertebral number rises in linear fashion from 32.45±.06 at 9-10 days to 33.14±.13 at 19-20 days.

It is interesting to note that even at 24.5°, vertebral numbers are higher than those of samples of Fundulus collected in the Woods Hole region which presumably are spawned at temperatures considerably lower than this. It is likely that development at a given temperature proceeds faster in nature than under less favorable laboratory conditions, and that, in addition, selection would favor more rapidly developing eggs and thus eliminate some of the higher numbers.

How does time of development affect the vertebral number? Any explanation attempted at present must necessarily be highly speculative. The idea was advanced long ago by Hubbs (1926) that accelerating conditions hasten growth inhibitors which terminate the addition of somites relatively sooner. This may be translated into terms of developmental processes on the assumption that as mesoderm cells become differentiated into muscle, sclerotome, etc., they lose the ability to become separated into somites. If histo-differentiation is more readily accelerated at high rates of development, it becomes precocious relative to the process of somite separation, and fewer vertebrae will be formed. Such a rate discrepancy would increase with time, so that one would expect the vertebral number to be affected in the region where the somites last form. It has, in fact, been shown (Ford, 1933 and others) that

the caudal region is the site of modifications in the number of vertebrae. It is possible, moreover, that the "complex" vertebrae, which are most common in the caudal region and at high temperatures, are produced by such rate discrepancies between somite separation and other aspects of differentiation.

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(This article is based upon a seminar report given at the Marine Biological Laboratory on August 4.)

THE EFFECT OF SOME VITAMINS OF THE B-COMPLEX ON RESPIRATION OF MUTANTS OF NEUROSPORA[1]

Drs. A. C. Giese and E. L. Tatum
Department of Biology, Stanford University

Wildier's discovery in 1901 of the necessity of bios for the growth of yeast was the beginning of our understanding of growth factors as requirements for lower organisms. Even before this time avitaminoses were being discussed, but it was not until the vitamin hypothesis was proposed by Funk in 1910 that the attention of physiologists was focused on these accessory food requirements of animals. Much research followed Funk's stimulus but the studies on vitamins needed by animals and of growth factors needed by lower organisms were performed independently. Only fairly recently has it become clear that the B-complex of growth factors of lower organisms is important to vertebrates and other animals as well as to higher plants.

Since not all animals and not all microörganisms must have all these vitamins or growth factors added to their diet or medium, the impression might exist that these factors are needed only sporadically and only by some peculiar organisms. It is true that many organisms grow perfectly well without being supplied with vitamins of the B-complex or need these only to begin growth, but in such cases vitamins are found to be already present, presumably being synthesized by the cells. Only when the organism is incapable of making its own vitamins must it be supplied with these from outside.

One might suppose substances so universally present to have some common function in the cell. The nature of this common function is implicit in the term "growth factor"; i.e., normal growth will not occur in the absence of the vitamin. Secondly, since the vitamins are necessary only in small quantities, it is clear that they must exert catalytic activity, and enzymatic action is at once suggested. It has been shown that of the eight recognized vitamins of the B-complex; B_1 or thiamin, B_2 or riboflavin (G), B_6 or pyridoxin, PP or nicotinic acid, pantothenic acid, p-aminobenzoic acid, biotin, and inositol, the following: B_1, B_2, nicotinic acid and biotin increase the rate of respiration (Stern and Oppenheimer, 1939). They are thus thought to catalyze directly or indirectly the reactions involved in respiration. In three of these cases the information is even more specific: thus B_1 is known to be the prosthetic group of pyruvic acid dehydrogenase and carboxylase; B_2 is known to be the prosthetic group of the yellow enzymes; nicotinic acid amide is part of cozymase. These enzymes are probably common to most if not all cells; these vitamins are thus common denominators of all forms of life—plants, animals and microörganisms.

The demonstration of the respiratory functions of B_1, B_2, nicotinic acid amide and biotin suggests that possibly the other vitamins of the B-complex act in a similar way, but no specific cellular function has yet been assigned to p-animobenzoic acid, B_6, pantothenic acid and inositol. It would thus be interesting to gain such data if it were possible. An unusual opportunity to do this for the first three of the above four factors presented itself when mutant strains of Neurospora requiring these growth factors were made available to the authors (Beadle and Tatum, 1941; Tatum and Beadle, 1942). Wild type *Neurospora crassa* and wild type *N. sitophila* need only biotin in addition to the sucrose and ammonium salts; each of the mutant forms requires in addition to these substances the particular vitamin which it can no longer synthesize: thus the "thiaminless" mutant requires B_1; "pyridoxinless", B_6; "p-aminobenzoicless", p-aminobenzoic acid; "pantothenicless", pantothenic acid, etc.

It should be pointed out that excepting their requirement of vitamins these mutant strains are apparently normal. Thus when each strain is supplied with the required vitamin, growth occurs in proportion to the vitamin supplied. When a completely adequate vitamin diet is supplied, growth occurs at the same rate and to the same extent for a given carbohydrate substrate as in the wild type. Excess of vitamin will not increase the rate of growth in the mutant once saturation has been reached. Addition of vitamins to the wild strain will not appreciably accelerate the rate of growth (Beadle and Tatum, 1941; Tatum and Beadle, 1942).

[1] Work supported by grants from the Rockefeller Foundation and from the Penrose Fund of the American Philosophical Society.

To determine if the vitamins mentioned above have a respiratory function, it is necessary to add the vitamin to cultures in the responsive state and to demonstrate a change in rate of respiration following such addition. Experiments were therefore performed using the standard Warburg technique.

The cultures grown in liquid in flasks were found to be quite variable, variations from flask to flask being as great as 100%. Even parts of the mycelium in a given flask showed great variations in rate per unit dry weight. Circulation of the culture fluid was therefore resorted to. A number of methods were tried: bubbling air, shaking with circular motion, shaking past barriers, shaking with glass beads, etc. While variation was greatly reduced by these procedures, it was not entirely eliminated. In no case did the germinating mycelium grow in a yeast-like form, although the concentration of nutrients, the volume of nutrients, etc. was varied. Homogenization of the mycelium with a butter homogenizer reduced the respiration to only a few per cent of the control. It thus became necessary to accept tthe variation and to conduct experiments in such a way that a control rate could be established in each respiration flask before additions of substrate or vitamin were made; in this way each flask constituted a control so that while cultures were somewhat variable, the percentage change produced by additions could always be significantly determined.

Experiments showed that when the "vitaminless" mutants were grown with adequate vitamins, the respiration was of the same order of magnitude as for the wild type. If to the mutants grown on adequate vitamin more vitamin is added, there is no increase in the rate of respiration. The same is true if the vitamin is added to the wild type. If the mutants are fed adequately with required vitamins but are starved for sucrose, then addition of more vitamins does not increase the rate of respiration, but addition of sucrose does. If, on the other hand, the mutant is given adequate sucrose, but is starved for the vitamin, then addition of the vitamin increases the rate of respiration. If the mutant is starved for both vitamin and sucrose, then there is an increase in the rate on addition of either of these. It thus appears that at least two factors limit the rate of respiration: (1) the concentration or activity of available enzyme and (2) the amount of substrate available. If substrate is present in excess, the rate will depend upon the concentration of enzyme or enzymes catalyzing the reactions resulting in oxygen consumption. An increase in oxygen consumption under these conditions means that the concentration of the active enzymes has been increased.

A few studies were first made with vitamin B_1 because its accelerating effect on respiration is well known for yeast and brain tissue. When the volume of oxygen consumed by the mycelium of the "thiaminless" mutant starved to the appropriate degree is plotted against tthe time, the rate of oxygen consumption is given by the slope of the line. For a period of several hours this is essentially a straight line, indicating a constant rate. Addition of B_1 results in a small but significant change in the slope of the line indicating an increase in the rate of respiration. This increase shows that the concentration of active enzymes available in the mycelium for utilization of oxygen has increased. The increase in rate in this case occurs fairly rapidly after the addition of the vitamin. No increase in rate of respiration followed addition of B_1 or any of the other vitamins in similar experiments when the mycelium was starved for too long a time.

In subsequent experiments the effect of vitamins whose respiratory function, if any, is unknown was studied. When pantothenic acid was added to a culture of a mutant which requires this vitamin for growth a significant increase in the rate of respiration was observed. This increase in rate of respiration indicates that this vitamin also effects the concentration of active enzymes concerned in respiration. Similar experiments were performed with vitamins B_6 and p-aminobenzoic acid with similar results.

In the last three experiments it was noted that the increase in rate of respiration occured more slowly than with B_1. It is possible that the rate of penetration is a limiting factor, but since a pH of about 4.5 is used, the organic acids are likely to be present largely in the more penetrating undissociated form. The rate of incorporation of the vitamin into the machinery of the cell might be the limiting factor, but it was found that when different concentrations of the vitamins were added, the increase in respiration was of about the same order of magnitude over wide limits. Finally, it is possible that the vitamins, perhaps combined to proteins, are enzymatically active in producing still other enzymes which then take part in the respiration of the cell. The upward trend in some of the curves following the addition of vitamins might possibly indicate some such indirect action.

We may conclude that the B-complex factors: p-aminobenzoic acid, pyridoxin (B_6) and pantothenic acid are involved in the respiratory mechanism of the cell of *Neurospora,* for in each case on addition of the vitamin there is an increase in the rate of respiration. The present experiments do not enable us to decide whether this effect is direct or indirect; however, experiments studying the effect of these vitamins on the respiration of intermediary metabolites may enable us to reach such a decision.

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(This article is based upon a seminar report given at the Marine Biological Laboratory on July 21.)

AGGREGATION OF SEPARATE CELLS OF DICTYOSTELIUM TO FORM A MULTICELLULAR BODY

Dr. Ernest H. Runyon

Associate Professor of Botany, Agnes Scott College

The fruiting body of *Dictyostelium* is fungus-like, consisting of a multicellular stalk anchored to the substratum, and a terminal mass of spores; but each cell of this structure was previously an independent protazoan-like amoeba (myxamoeba). Thousands of amoebae, after a period of feeding and multiplication come together in characteristic patterns forming a pseudoplasmodium, in which there are no cell fusions, but nevertheless, as has been well-demonstrated by Raper, definite coordination and dominance. The pseudoplasmodium is the immediate precursor of the fruiting body.

Study of the aggregation phase was found to be facilitated by the use of non-nutrient agar over which are thinly spread the amoebae, previously washed, concentrated and roughly separated from the associated mass of bacteria by centrifuging. Size, pattern and rate of development of aggregates are much affected by the thickness of the film or layer of water in which the amoebae are dispersed. If the culture is relatively dry (the aqueous film very thin) collecting points (centers) are many, and aggregation progresses rapidly. In thicker films aggregation is slower, centers fewer and the amoebal strands leading to the centers longer and less compact. Under these conditions, also, spiral aggregation patterns are frequent. Under water 0.2 to 0.5 mm deep the aggregation pattern is a network of amoebal clumps connected by much elongated but loosely placed amoebae; there are no well-defined centers nor compact strands. The aggregation influence seems to be diffuse. Under water deeper than 1 mm. aggregation has not been observed, but the relatively small proportion of the amoebae that comes into the surface does aggregate there. Potts in 1902 recorded fruition of *Dictyostelium* under oil. The pattern and rate of aggregation under a layer of paraffin oil is much the same as without the oil: the collecting points are many and aggregation progresses rapidly. Aggregation with center determination occurs under a glass cover slip or dialyzing membrane (Visking) placed over the amoebae on agar. Amoebae which are on top of such a dialyzing membrane become oriented corresponding to patterns of aggregation below the membrane; the amoebae on top accumulate along strands and centers below the membrane. Thus it seems likely that the determination of centers of aggregation depends upon the diffusion of a substance that is water- but not oil-soluble, active in thin films and of a molecular character such that it can pass through a dialyzing membrane.

(This article is based upon a seminar report given at the Marine Biological Laboratory on August 18).

GENETIC AND CONSTITUTIONAL CAUSES OF FETAL DEATH

Dr. Philip Levine

Division of Laboratories, Newark Beth Israel Hospital

In the course of studies on the cause of intragroup transfusion reactions in pregnant women, the concept of isoimmunization of the mother by hereditary dominant agglutinable factors in fetal blood was suggested as the origin of the atypical agglutinins which were held responsible for the poor results of the transfusions. The particular antigenic factor involved was shown to be related to the Rh (rhesus) factor of Landsteiner and Wiener, because the specificity of the maternal atypical agglutinins and that of the anti-rhesus immune serum, produced experimentally, were identical.

The phenomenon of isoimmunization of the mother, whose blood did not contain the Rh factor (Rh—) by the Rh factor (Rh+) in fetal blood, was shown to be correlated with a high incidence of fetal death and, more specifically, with the disease of the fetus and the new-born, called erythroblastosis fetalis.[1] Although the characteristic features of this disease—familial incidence and intra-uterine hemolysis—were thoroughly described clinically, the cause of the disease was unknown. Three clinical forms are generally recognized: (1) fetal hydrops (mainly stillborn), (2) icterus gravis and (3) anemia of the new-born. There is now sufficient evidence of serologic and statistical nature to indicate that (1) the Rh— mother is immunized by the dominant hereditary Rh factor of fetal erythrocytes, and thus produces

anti-Rh agglutinins, and (2) the anti-Rh agglutinins pass through the placenta to react with the susceptible fetal blood, thus inducing intra-uterine hemolysis.[2]

Without going into the serologic details, the statistical evidence for this concept is given below.[3]

Blood Studies of	Incidence of Rh factor in red blood cells	
	+	—
Random population	85%	15%
350 mothers of erythroblastotic infants	10	90
204 husbands of Rh— mothers	100	0
139 affected infants of Rh— mothers	100	0

In 10% of the cases, other agglutinable factors A, B, Hr or still other unknown factors in fetal erythrocytes may immunize the mother. The factor Hr demonstrable by means of an agglutinin produced by an Rh+ mother of an erythroblastotic infant is related genetically to the Rh factor, perhaps allelomorphic.

The striking familial incidence of erythroblastosis fetalis in certain matings in contrast to the sporadic incidence in other matings can be understood in terms of the homozygous (Rh Rh) or heterozygous (Rh rh) nature of the Rh factor in the father's blood. In both sorts of matings the first one or two pregnancies with Rh+ fetuses may result in normal infants, but these pregnancies serve to stimulate a sufficient degree of isoimunization so that all subsequent Rh+ infants are affected with one of the three clinical varieties of erythroblastosis fetalis.

It is not as yet possible to differentiate serologically homozygous and heterozygous individuals. However, if one of the surviving children is Rh—, then the father must be heterozygous so that this family may be advised that they have 50% chance for normal (Rh—) infants in their future pregnancies. In view of the high incidence of pregnancy wastage in those matings where the father is suspected to be homozygous, further pregnancies should not be encouraged.

From the point of view of fetal death and neonatal morbidity, erythroblastosis fetalis is not very important because it occurs only in 1 in 200 to 1 in 400 deliveries. Although 13% of all random matings are such that the father is Rh+ (85%) and the mother is Rh— (15%), only a small number of these Rh— women are capable of producing anti-Rh agglutinins.

Erythroblastosis fetalis assumes an importance altogether out of proportion to its low incidence, because it serves as an example in man of fetal death and neonatal morbidity attributable to genetic and constitutional considerations. It is noteworthy that although based on dominant heredity, the father is invariably normal, i.e., he never had erythroblastosis fetalis in his infancy. Another feature of importance is that erythroblastosis has a selective effect only on Rh+ fetuses and infants. Thus there are twins only one of whom is affected because this member was Rh+ and the other is Rh— and, therefore normal.

Granted that a particular factor in fetal blood, Rh, may immunize the mother with resulting pathologic effects on the fetus or infant, the question arises why isoimmunization induced by other blood factors may not also result in morbid effects on the fetus and new-born. This question is especially pertinent in view of the high incidence of unexplained early and late fetal deaths and because of the great individuality of human blood resulting from the permutations and combinations of a number of well-described hereditary blood factors in addition to Rh, such as A and B (blood groups), M, N, P and still others. By the same token, i.e., individuality of animal blood, the same phenomenon of isoimmunization of the mother by dominant hereditary blood factors in the fetus may be expected to be operative in causing selective fetal death in numerous, if not all species of animals.

Actually there is already evidence that the factors A and B in fetal red blood cells may immunize the mother who lacks these factors, with resulting abortions and stillbirths. This immunization is evidenced by a specific increase in the normally present isoagglutinins anti-A or anti-B. Such immunization can occur only in those matings in which the dominant factor A or B is present in the father's blood but not in the mother's blood. This sort of mating, termed incompatible, occurs in 35% of all random unions, but in a selected group of 150 cases characterized by two or more instances of early or late fetal death, the incidence of incompatible matings was found to be as high as 54%.[4] Obviously, there are a number of other causes responsible for fetal death in this heterogeneous group, in contrast to the clinical entity of erythroblastosis fetalis, so that, a priori, the statistical proof could not be expected to be as convincing as in the Rh series.

Still other lines of evidence will be presented elsewhere but reference may be made here to an old observation of Hirszfeld[5, 6] that in the matings A father x O mother the incidence of A offspring is less than in the matings O father x A mother, presumably because of selective fetal death. This significant finding could be confirmed by Levine[7] in an analysis of six out of seven additional heredity studies.

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The Collecting Net

A weekly publication devoted to the scientific work at marine biological laboratories.

Edited by Ware Cattell with the assistance of Judy Woodring and Jane Woodring.

Entered as second-class matter, July 11, 1935, at the U. S. Post Office at Woods Hole, Massachusetts, under the Act of March 3, 1879, and re-entered, July 23, 1938.

BIOLOGICAL STUDIES AT WOODS HOLE IN WINTER

Dr. Laurence Irving

Professor of Biology, Swarthmore College

Some of the familiar marine animals of Woods Hole have quite different habits in winter and summer. When Mr. Niels Haugaard wished to measure the respiration of the common cunner during the Christmas vacation, he learned from Mr. McGinnis that it was usually impossible to catch cunners after October and that it would be necessary to catch and hold them in live cars. Mr. McGinnis feared that the cunners would not survive a spell of really cold weather, for they are frequently killed by the winter temperatures prevalent in the water along the shore.

When the respiration of the winter cunners was examined, it was found that at any endurable temperature they consumed a little more oxygen in winter than at the same temperature in the summer. A certain amount of acclimatization had accelerated their metabolism in the winter, but the winter change was small, and the resting output of energy by the cunner was at a low rate in the prevailing winter temperature. It may well be that the metabolism is so depressed by cold that they cannot maintain in winter the activity needed for life in their usual summer habitat.

In February, which gives the coldest water temperatures, Mr. George Edwards came to Woods Hole to examine the respiratory metabolism of the sand crab, *Emerita talpoida,* which he had already studied in detail during the summer. These animals are abundant in the sand at Nobska beach in summer, but in February none could be found along the beach line nor even by digging several feet into the sand. A week's search of beaches and shore lines with the help of Mr. McGinnis failed to find the *Emerita.* Finally, by systematic dredging the animals were found in deeper water off Nobska. Two distinct concentrations were found. The small ones lived in a restricted area of the bottom in about 6 - 8 feet of water, and the larger ones in another area at about 12 - 14 feet. Frequent search thereafter by Mr. McGinnis showed that *Emerita* returned to the shore line about May first.

The metabolism of *Emerita* was considerably greater at low temperatures in winter than in summer, and in winter 26° was fatal while 36° was tolerable in summer. There was thus a distinct alteration in the winter *Emerita,* and its effect would be toward keeping up metabolism at low temperatures in winter. The water in which they were found in winter was at —1.5° C. Their short migration did not evade the cold, and as suggested by figures showing sustained growth rate in winter, their metabolism was maintained by internal adjustments which in some degree countered the depressant influence of winter temperature.

These preliminary observations on the physiological changes in common animals during the seasons suggest that outside of July and August occur interesting changes in their habits. The natural history of many of these forms which are familiar in summer is obscure in winter, and we often know only a brief stage in an elaborate life cycle. Determination of winter habits of the common animals will correct and extend our descriptions of their general biology, and the natural experiment resulting from change of season excels in significance any artificial experimentation. These are advantages which winter study at Woods Hole can bring to complete our views and refresh our minds.

On Thursday, August 27, Dr. Oscar W. Richards of the Spencer Lens Company, for a number of years in charge of the Chemical Room of the Laboratory, gave a lecture entitled "The Precision of Sectioning with a Microtome." The following evening, a regular lecture, entitled "Evolutionary Chromosome Changes in Sciara as Shown by the Giant Salivary Gland Chromosomes" was presented by Dr. C. W. Metz.

Two seminar reports were given on Tuesday evening, August 25. Dr. G. M. Everett presented a paper on "Vitamin B deficiency in the cat," which was accompanied by colored moving pictures, and Dr. T. H. Bissonette spoke on "Experimental modification of molts, and color-changes by controlled lighting of the Bonapart weasel."

Two more meetings were held this week by the group of biologists who assembled earlier in the summer to consider the relationship of biologists to the war. Last Saturday they met with Dr. Robert F. Griggs, Chairman of the Division of Biology and Agriculture of the National Research Council.

ITEMS OF INTEREST

The Invertebrate Course of the Marine Biological Laboratory completes its work on Saturday, August 29.

The "Mess Hall" of the Marine Biological Laboratory will remain open until September 15 and perhaps several days longer, the closing date depending on the number of investigators eating there. 120 people were eating there on August 27. The maximum number of persons served at any one meal during the summer was 150 at dinner on July 23.

The annual symposium of the Society for the Study of Development and Growth convened at North Truro on the Cape beginning on Monday and running through Thursday afternoon of this week. About sixty biologists attended the meetings; among those from this Laboratory were: Professor Otto Glaser, Dr. Dorothy Wrinch, Professor B. H. Willier, Dr. E. H. Runyon, Miss Jane Bridgman, Dr. Paul Weiss and Dr. R. Bloch.

Dr. B. H. Willier was elected President of the Society for the Study of Development and Growth at the closing session of the Society on Thursday afternoon.

Among those who have been recently visiting the Marine Biological Laboratory are: Professor Abbey Turner, Mt. Holyoke College; Professor J. A. Reyniers, University of Notre Dame; Alexander Weinstein, Columbia University; Professor Waldo Schumway, University of Illinois (at present with the Government in Washington), Dr. Birdsey Renshaw, Oberlin College; Dr. and Mrs. R. L. Burt and David Todd, Harvard Medical School.

Dr. Robert F. Loeb, son of the Late Jaques Loeb, has been appointed Lambert Professor of Medicine at the College of Physicians and Surgeons of Columbia University.

Dr. Walter B. Cannon, George Higginson Professor of Physiology at Harvard University will retire on September 1 and become an emeritus professor. Dr. Cannon has been a member of the Department of Physiology since he graduated from Harvard forty-two years ago.

Dr. Donald Duncan, associate professor of anatomy of the Faculty of Medicine of the University of Texas, has been appointed professor and head of the Department of Anatomy at the University of Buffalo School of Medicine.

Dr. Donald Slaughter has been appointed professor of pharmacology at the University of Vermont. He formerly held the position in the College of Medicine of Baylor University.

Dr. Ballentine, who has been a National Research Council fellow of the Rockefeller Institute working on the structure of the cell surface, has been appointed lecturer in zoology at Columbia University.

Dr. Libbie H. Hyman visited Woods Hole this week and lectured before the Invertebrate Class.

Dr. Paul Weiss, professor of zoology at Bryn Mawr College, is a contributor of an article entitled "Mortality and Ethics" in the July 2 issue of *The Journal of Philosophy.*

Professor Ross G. Harrison, trustee emeritus of the Marine Biological Laboratory, is working in Washington about two-thirds of the time where he serves as chairman of the Division of Biology and Medicine of the National Research Council. The balance of the time he is at Yale.

Dr. O. L. Inman, Director of the Kettering Foundation for research in chlorophyll and photosynthesis at Antioch College died in July. In past years Dr. Inman has worked at the Marine Biological Laboratory.

Dr. F. O. Schmitt has been visiting Woods Hole for a couple of weeks with his family.

Mr. William S. Metz, son of Dr. C. W. Metz, paid an unexpected visit to Woods Hole last week. He is now in the aviation corps and is stationed at Napier Field in Alabama.

Dr. I. Lorberblatt, Captain, now stationed in the Medical Corps at Camp Edwards who worked here in the late '20s with Leo Loeb, visited Woods Hole recently.

Mary Goodrich married Dr. Nevin Scrimshaw at the end of last summer. During the past year he was instructor in the Department of Zoology at Ohio-Wesleyan University. Dr. Scrimshaw is now taking the medical course at the University of Rochester and working as research assistant to Dr. Murlin.

The Biological Laboratory at Cold Spring Harbor, N. Y.. recently acquired, as the gift of Mrs. Henry W. de Forest, two tracts of land of about fifteen acres adjacent to the laboratory property. One tract contains a building suitable for living quarters; the other includes the long stretch of beach which has been used extensively as a collecting ground.

RESEARCH WORK AT THE ATLANTIC BIOLOGICAL STATION, ST. ANDREWS, NEW BRUNSWICK

A. W. H. Needler
Director

This is the Atlantic biological station of the Fisheries Research Board of Canada, corresponding to the Board's Pacific Biological Station at Nanaimo, British Columbia. The aim of the station's work is to provide, through biological investigations, an adequate basis of knowledge for the sound administration and exploitation of the fisheries on the Atlantic coast of Canada. In its attempt to assist our fisheries it is associated with the Board's Fisheries Experimental Stations at Halifax, Nova Scotia, and Gaspe, Quebec, which are concerned principally with methods of processing fishery products after they are landed.

The station has a full-time scientific staff of ten, now somewhat reduced by absence of some of its members in the armed forces. A few scientists are also employed seasonally on the Board's problems. Limited facilities are offered to scientists engaged in other work at their own expense.

The principal laboratory is at the mouth of the St. Croix River estuary tributary to Passamaquoddy Bay and in turn to the Bay of Fundy. There is open water throughout the year and the large tides bring conditions approximating those of more exposed waters close to shore. The main laboratory building is fire-proof. The station is equipped with running salt water, an experimental trout hatchery and rearing ponds, low-temperature rooms, and a small cold storage as well as more usual laboratory facilities.

The Board has, in peace time, operated a small sea-going motor vessel in connection with the station. It has been taken over by the Navy for the duration of the war.

In addition to the principal laboratory at St. Andrews there is a sub-station at Ellerslie, Prince Edward Island, which was established principally for oyster culture investigations. The conditions in Malpeque Bay, on which it is situated, differ widely from those at St. Andrews. The water is much warmer in summer and ice-covered in winter, and forms occur which, like the oyster, require high temperatures for reproduction but can withstand very low temperatures for part of the year.

The scientific investigations carried on at the station have the definite practical aim of assisting the fisheries by guidance of government policy and by developing methods of culture or exploitation. This aim can be realized only by giving attention both to discovering the fundamental principles involved and to applying them. A close association both with the industry and the administration is necessary. The practical aim governs the choice of subjects for investigation to a large degree and requires effort to make the results effective. In this effort both the scientist and the man who is to apply the results must share.

Although reduced during war time by a reduction of facilities, much work has been done in the past on the "deep sea" fisheries and will be resumed when conditions warrant. In this field the aim is to improve the exploitation of the stocks of fish through increased knowledge of their movements, prediction of their abundance and regulation of the fishery rather than to increase the stocks. A knowledge of the hydrographic conditions is of fundamental importance and hydrographic investigations have played a large part in the station's work in the past. Their resumption is necessary to a better understanding of the factors controlling the movements and abundance of the fish. The life histories, migrations and abundance of the fish themselves have also been studied, attention having been given among others to cod, haddock, herring and mackerel. Much of the general background has been discovered but more remains to be learned, especially of the effects of the fisheries on the stocks and perhaps more important, of the maximum yields which can be maintained. It is hoped that much more progress can be made in the future.

Of the inshore fisheries special attention has recently been given to lobsters and to smelt. In both these fisheries there is great variation from place to place and both are more subject to intensive fishing and more susceptible to administrative control than are most deep sea species.

The lobster fishery has been the subject of investigation for a number of years. Growth rates, size, composition of the stocks, moulting seasons, etc., have been studied on various parts of the coast. Special attention has been given to the southern Gulf of St. Lawrence where reproduction is good, growth relatively rapid, the fishery intensive and the industry dependent to a large degree on the canning of relatively small lobsters. In this region is has been shown that the average size tends to be relatively low where the fishing is most intense (catching over half of the lobsters of catchable size each year in some districts). It has also been shown that the lobsters are more easily caught as they become larger. Recently minimum size limits have been imposed and then increased and the effects are being studied.

An intensive investigation of the smelt fishery, centered in the Miramichi estuary, has recently been started. There is some possibility that the fishery has been intensive enough to reduce the annual yield. The investigations are aimed to discover how the fishery may be regulated to obtain the maximum continual catch.

For about twelve years investigations of oyster cultural methods have been carried on in connection with the government's policy of encouraging oyster farming. At the sub-station at Ellerslie the Department of Fisheries has maintained an experimental oyster farm at which cultural methods suited to the local conditions have been tested on a commercial scale. The administration of the oyster farming industry has been very closely associated with the station's work, and results have been promising. Methods of spat collection, rearing of small oysters, control of enemies, etc., have been developed as well as administrative policies based on a knowledge of local conditions. This work, which started in the Malpeque Bay region, has been gradually extended to other oyster areas where widely different hydrographic conditions have presented special local problems.

Investigation of methods of culture of the soft-shelled clam (Mya) have recently been started in the Bay of Fundy area and attention has also been given to quahaugs (Venus) and other inshore bivalves.

In the fresh water field the work of the station has included a study of hatchery problems, especially the feeding of young trout and salmon and the causes of hatchery mortalities. The effectiveness of the planting of hatchery stock and the natural productivity of various bodies of water has also been studied. The proper use of hatchery stock presents more difficult and more important problems than the actual production of that stock. The returns from hatchery plantings and from naturally produced fry are being studied in relation to the physical and biological conditions of the waters with the aim of developing the best possible use of the former.

We have mentioned only some of the principal fields of investigation, and there are many others, some of which may increase in importance. The problems of the fisheries are innumerable and complex, and within its general field the work of the station changes frequently. Among the less important subjects of investigation at the present time might be mentioned: the exploitation of our sea-weeds, especially Irish moss; the less important commercial fish such as silversides (Menidia), tomcods (Microgadus), and striped bass (Roccus); and the scallop fishery (Pecten grandis) which is likely to assume more importance in the work of the station.

THE OFFICIAL MEETINGS OF THE MARINE BIOLOGICAL LABORATORY

(Continued from Page 81)

chosen. The office of Vice-President was created, and was filled by the election of Dr. E. Newton Harvey, professor of physiology at Princeton. Mr. Donald Brodie was made Treasurer. He is not a stranger to Woods Hole. For many years he was associated with Mr. Crane, and thus became familiar with the affairs of the Laboratory. Dr. Otto Glaser was elected Clerk of the Corporation in place of Dr. P. B. Armstrong, who resigned. These officers assume their new responsibilities at a critical time. We are confident that under their leadership this institution will continue to serve its primary purpose of encouraging biological research, and will maintain its prestige.

The Trustees elected eleven new members of the Corporation and named Dr. Glaser and Dr. Metz to serve on the Executive Committee. The Coroporation re-elected all the Trustees whose terms of office expired this year, and elected Dr. Eric Ball and Dr. E. F. Dubois to fill the places of Dr. A. P. Mathews and Dr. S. O. Mast, who were made Trustees Emeritus. Finally, Dr. Lillie was elected President Emeritus.

Mr. Riggs, as Treasurer, reported that the Laboratory is free from indebtedness and has a small reserve fund. The Director showed, by means of charts, how the annual income has dropped in the last two years from $170,000 to $130,000. To balance the Budget, the Executive Committee has been forced to make drastic cuts in the appropriations for many of the departments, particularly for research and for the Library. While it is true that we can not now buy much apparatus nor receive and pay for foreign journals, we shall presently have to expend considerable amounts for both of these essential items of our equipment.

Dr. Little explained how apparatus now must be repaired and altered to serve new needs, and emphasized the fact that investigators must adapt themselves to these unwelcome conditions. The Librarian, Mrs. Montgomery, spoke of the microfilm service which is now in operation. Already it is extensively used. Indeed, we soon may be unable to fulfill all the requests for films.

In the present conditions, it is difficult, if not impossible, to predict the future. But we must assume that next year, research and instruction will continue here at Woods Hole. In the fifty-five years of its existence, this Laboratory has maintained these activities without interruption. Every effort will be made to keep them in full operation.

INVERTEBRATE CLASS NOTES

By next Monday the Invert Class will be scattered, grads and undergrads, priests and professors. The majority of the students are undergraduates and will be going back to school within a few days after the end of the course.

George Waterman isn't getting much of a break though, as he is leaving to make an eight o'clock lecture on Monday. He teaches comparative anatomy and general zoology at Assumption in Worcester and is riding back with some of the gang in "Fogg's folly."

Ginny Hufford and Marge Brearly are studying and assisting at Holyoke this fall. Marge takes her master's in November. Jim Foster is hoofing back to Amherst, where he is also assisting this year.

The picnic at Tarpaulin Cove was a treat for everybody, especially after a month's sojourn at Stony Beach. Maddie Philbrick, who headed the picnic committee, with the able assistance of Miss Johnson, did a swell job of getting everything together.

In all seriousness, however, the Class will leave the M.B.L. with regret, and we hope that many of us will return next summer. So, until next summer, so long M.B.L.—*N. W. F. and E. C.*

Dr. George W. Hunter, assistant professor of biology at Wesleyan University, has become Captain in the Sanitary Corps of the U. S. Army and is stationed in Washington, D. C., where he is teaching parasitology.

Miss Margaret Mast, daughter of Dr. S. O. Mast, has taken a position at the General Electric Company.

GENETIC AND CONSTITUTIONAL CAUSES OF FETAL DEATH

(Continued from Page 89)

So far as selective fetal death in animals is concerned, the significant observation of Corner[8] may be cited as an example. In the absence of a more suitable explanation, Corner attributed selective intra-uterine death in pigs to genetic and constitutional considerations. The evidence presented on isoimmunization by the fetus as the cause of fetal death in man is compatible with the general concepts of Corner and thus opens up a vast field for future investigation.

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(This article is based upon a paper read before a special group at the Marine Biological Laboratory on July 20. The work was aided by a grant from the Blood Transfusion Association of New York City and the National Committee of Maternal Health.)

Mr. Robert F. Bowman, who had wide acquaintance among the investigators at the M.B.L., died in April. He was president of The Blakiston Company.